PB-216 713

MINIMUM REQUIREMENTS FOR PREVENTION OF INDUSTRIAL WASTES POLLUTION. RECOMMENDED SEWAGE WORKS DESIGN STANDARDS. WATER QUALITY OBJECTIVES

E. F. Eldridge, et al

Pollution Control Council
Portland, Oregon

September 1952

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

~~338~~
552

PB 216 713

POLLUTION CONTROL COUNCIL

PACIFIC NORTHWEST AREA

" MINIMUM REQUIREMENTS FOR PREVENTION

OF INDUSTRIAL WASTES POLLUTION "

" RECOMMENDED SEWAGE WORKS

DESIGN STANDARDS "

WATER QUALITY OBJECTIVES

1952

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

STATE OF WASHINGTON
STATE OF OREGON
STATE OF IDAHO

STATE OF MONTANA
PROVINCE OF BR. COLUMBIA
TERR. OF ALASKA

MINIMUM REQUIREMENTS FOR PREVENTION OF INDUSTRIAL WASTE POLLUTION

Pollution Control Council

Pacific Northwest Area

By:

Committee on Industrial Waste Standards

Mr. E. F. Eldridge, Chairman
Mr. Kenneth Spies, Member

Revised September 1952

INDEX

	Page No.
Members of Pollution Control Council	I
Committee's Letter to Council	II
Introduction	1-2
MINIMUM REQUIREMENTS For:	
Slaughterhouses and Meat Packing Plants	3
Poultry Killing and Packing Plants	4
Milk and Milk Products Plants	4
Canneries, Vegetable and Fruit	5
Canneries, Fish and Shellfish	5
Wineries	6
Breweries	6-7
Saw Mills, Veneer Mills, and Other Wood Handling	7-9
Oils and Like Material	9-12
Tanneries	12-13
Beet Sugar Factories	13-14
Coal Washeries	14
Gravel Washeries	14
Flax Processing	15
Dehydration, Potatoes and Fruits	15
Metal Industry	15
Pulp and Paper Mills	16

I

MEMBERS OF POLLUTION CONTROL COUNCIL

PACIFIC NORTHWEST AREA

Alaska

A. J. Alter, Director
Div. of Sanitation & Engineering
Territorial Department of Health
Juneau, Alaska

Idaho

H. C. Clare, Director
Public Health Engineering
State Department of Public Health
Boise, Idaho

Oregon

C.M. Everts,Jr., Sec. & Chief Engr.
Oregon State Sanitary Authority
Portland, Oregon

Montana

**C. W. Brinck, Director
Div. of Sanitary Engineering
State Board of Health
Helena, Montana

British Columbia

*Reginald Bowering, Director
Div. of Public Health Engineering
Department of Health and Welfare
Victoria, British Columbia

Canada

A. H. Perry, Supervising Engineer
Public Health Engineering Div.
Dept. of National Health & Welfare
Vancouver, British Columbia

Washington

Emil C. Jensen, Chief
Div. of Public Health Engineering
Washington State Dept. of Health
Seattle, Washington

E. F. Eldridge, Director & Chief Engr.
Washington Pollution Control Commission
Olympia, Washington

United States

R. R. Harris, Sr. Sanitary Engineer
Division of Water Pollution Control
Public Health Service
Federal Security Agency
Portland, Oregon

---

* Mr. Norman Goode represented British Columbia during Mr. Bowering's assignment in Korea during 1951.

** Mr. H. B. Foote represented Montana from January 1949 to September 1951.

Members of the Pollution Control Council
Pacific Northwest Area
Office of the Secretary
Portland, Oregon

The Committee appointed by the Pollution Control Council, Pacific Northwest Area, to prepare minimum requirements for the prevention of industrial waste pollution hereby submit such requirements for the industries indicated. The industries covered represent those of major importance in the area. As need arises and information becomes available, other industries should be included together with the respective requirements

COMMITTEE:

E. F. Eldridge

E. F. Eldridge, Director & Chief Engineer, Washington Pollution Control Commission

Kenneth H. Spies

Kenneth H. Spies, Assistant Chief

MINIMUM REQUIREMENTS

FOR THE

PREVENTION OF INDUSTRIAL WASTE POLLUTION

INTRODUCTION

Pollution by wastes from industry exceeds by many times that resulting from domestic sewage. One of the reasons for this high pollution load is the lack of understanding on the part of certain industrial management of the effects of industrial pollution. Much of the load contributed by industry can be eliminated by careful operations and comparatively inexpensive waste prevention measures. Waste saving measures have been known to result in profit to certain industries. The true value of these measures, however, is in the reduction of the pollution load on public waters or on the operation load applied to municipal sewage treatment facilities in case the industry has access to the municipal system.

The minimum requirements listed below are designed to bring about more careful industrial operation and to promote waste prevention. To be of most value they must be, and are, applied on an industry-wide basis and as such will constitute a fair and reasonable means of reducing industrial pollution. It is expected that in some cases these measures will not be sufficient to solve a pollution problem and that further reduction by waste treatment will be necessary. However, waste treatment should not be required until waste prevention has been given a fair trial.

The staff of the various pollution control agencies should be available to discuss the problems created by these regulations. Plans for installations to be used to comply with them should be submitted for approval before they are constructed. In this way the experience of the staff will be made use of in providing effective facilities.

Waste materials resulting from waste prevention measures as provided for by the minimum requirements below must be disposed of in such a manner as to insure that they will not, either directly or indirectly, enter any natural waters.

The following definitions will apply to terms used herein:

Industrial wastes are the water-borne wastes resulting from industrial processes or from the development of a natural resource.

Waters of the State includes all rivers, streams, ponds, lakes, inland waters, underground waters, salt waters, and other surface waters and watercourses within the jurisdiction of the State in which the regulations are applied.

Slaughterhouses and Meat Packing Plants

1. Yards and holding pens shall be dry cleaned before washing down.

2. Kill blood shall be separately collected and the blood thoroughly squeegeed from the floor into the collection tank. The disposal, or utilization, of the blood thus collected will depend on local facilities, but must be accomplished in a manner which conforms to sanitation regulations.

3. Paunch manure and hog stomach contents shall be collected separately and used as fertilizer, land-fill, or in any other satisfactory manner. A fine screen is recommended wherever its installation is feasible.

4. Fleshings, grease particles, and other solid material shall be collected by dry cleaning of floors and screening of wastes.

5. Adequate grease recovery basins shall be installed on drain lines from by-product processing rooms. These traps shall be skimmed and cleaned at least once each day. (Note: In the larger plants it is recommended that small basins be located wherever high-grade greases can be recovered in significant quantity and that a main basin be installed on the main drain line. Wastes not containing grease should be by-passed around the basin.)

Poultry Killing and Packing Plants

1. Provision shall be made for the collection of blood from the killing and bleeding and for the disposal of this blood in a satisfactory manner.

2. All manure, feathers, entrails, and other material removed from the carcass of the fowl shall be collected and the floor and equipment thoroughly dry cleaned before washing down. Provision shall be made for the proper disposal of this material.

Milk and Milk Products Plants

1. Whole milk, skim milk, buttermilk, whey, condensed milk products, dried milk products, or spoiled milk or milk products shall not be dumped or otherwise allowed to enter a drain line which leads, either directly or indirectly, to a State water.

2. Mechanical can washers, both straight-line or rotary, shall be equipped with a drip collector and the drip milk collected and disposed of in a manner which conforms to sanitation regulations.

3. Milk or milk products left in sanitary lines, tanks, and equipment before washing shall be drained into suitable containers and disposed of in a satisfactory manner as directed above. It is recommended that these lines and equipment be installed to slope slightly to the point of collection.

4. Leaks in pumps, pipe lines, and other equipment handling milk or milk products shall be repaired as rapidly as possible.

5. Accidental spillage shall be reduced to a minimum by providing appropriate alarms or automatic equipment to prevent such accidents and by proper instruction to personnel.

Canneries, Vegetable and Fruit

1. Vegetable and fruit canneries (unless other arrangements are made with the appropriate State pollution control agency) shall provide an efficient screen for the removal of skins, seeds, pomace, culls, discarded products, and other suspended material from the wastes from the washing, sorting, or other canning processes. This screen must be U. S. standard 20-mesh and may be of the vibrating, rotary, or any other effective type. It shall be located on the main outlet sewer line or lines from the cannery in such a way that all waste waters will pass through the screen except cooling, condenser or other clean waters. The latter may be by-passed around the screen or discharged through a separate outlet. Prior to the installation of the screen a plan drawing of the facility shall be submitted to the appropriate State pollution control agency for approval, together with data as to capacity.

2. Screenings and other solid material removed from the product during the cannery operations shall be disposed of in a manner which will assure that it will not enter a State water.

Canneries, Fish and Shellfish

1. Discarded portions of fish and shellfish products which result from cleaning, sorting, and other cannery or fish product operations shall be collected and disposed of in a manner which will prevent these materials from entering a State water. (It is suggested that arrangements be made with rendering plants for collection of this material at regular intervals. This will necessitate the installation of a hopper or other suitable containers as well as screens over floor drains to retain the solids.)

Wineries

Wastes from dry wine production consist of pomace, lees, and wash waters. In addition, the manufacture of wine or brandy will produce still slops from the distillation process.

1. Pomace, which is a garbage-like material, shall not be allowed to enter the liquid waste waters. If disposed of on land, the location of the disposal field shall be such that seepage water from the pile will not enter a surface water and that flood waters will not carry the material into public waters. Prevention of ground-water contamination in the area must also be considered in the location of the field.

2. The major portion of the lees shall be separated and disposed of along with the pomace, unless arrangements are made by agreement with the appropriate State pollution control agency and the respective municipal officials for disposal in a municipal sewage system and treatment plant. If discharge to a municipal system is approved, facilities to spread the discharge over a period of time, rather than in batches, must be provided.

3. Still slops shall not be disposed of in the sewer system. This waste product disposal is a locality problem and is subject to the same requirements given for pomace if land disposal is used.

Breweries

1. Under no condition will brewers' grains be discharged to the sewer system. (Note: Grains have a definite market value and are almost always recovered and sold for cattle feed; however, provision must be made for holding or storage in case of breakdown or delay in transportation.)

Breweries (Continued)

2. Because of high concentration of grain liquor, grain should be sold in a wet condition. In case the grain is dehydrated, special arrangements must be made for the disposal of the liquor by agreement with the appropriate State pollution control agency.

3. Spent hops shall be collected and disposed of as fertilizer, dumping on land, incineration or in some manner as to prevent this material from entering State waters.

4. Methods shall be devised for the separation and recovery of the yeast to prevent its entrance to the liquid waste drains.

Saw Mills, Veneer Mills, and Other Wood Handling

1. Sawmills and veneer plants located in close proximity to any waterway should take the following precautions in the disposal of waste sawdust, bark, slabs, and trimmings:

A. At the mill site, wastes should be kept out of any adjacent waterway and should be kept above the highwater mark and not in such a place that they will later be washed to the water. (Note: Underwater cutting is the cause of a considerable water pollution problem due to the formation of banks and piles of sawdust in the water. It is strongly urged that this practice be discontinued on an industry-wide basis, or that the area where the cutting is done be confined and the accumulated material disposed of on land.)

B. If debris is to be burned, a properly constructed burner is to be used and consideration given to the following:

Saw Mills, Veneer Mills, and Other Wood Handling (Continued)

(a) The burner should be well enough away from the water or other provisions be made, so that unburned wastes will not escape from the burner, either on the ground or through the air to the waterway.

(b) Chutes which cross a waterway when leading from the mill to the burner should be constructed in such a manner that wastes will not fall from the chute to the waterway.

(c) Burned-out screens and sections should be patched or replaced.

(d) Chutes carrying wastes to a burner under forced draft should be deflected downward or passed through a hopper or a series of baffles so that fine sawdust will tend to settle to the fire and not be carried out the screen.

Reproduced from best available copy.

C. Sawmills which truck sawdust and slabs away from a mill site should have these wastes dumped away from waterways, and in no case should sawdust and slabs be dumped below the high-water mark of the waterway or in such a position that they may be later washed or leached to the waterway.

2. When log ponds are located near watercourses, the following precautions should be observed:

A. No log pond should be located in such a manner that the entire stream flows through the log pond.

Saw Mills, Veneer Mills, and Other Wood Handling (Continued)

2B. The overflow should be regulated in such a way that the amount of sawdust, chips, and suspended materials that reach the waterway is reduced to a minimum.

C. Log ponds should be cleaned by dragging and dredging, rather than by flushing into a stream or river.

3. The sanitary and other provisions of the State and County Health Departments regarding logging and milling in watersheds above sources of drinking water supplies are to be carefully followed:

A. Permanent and semi-permanent camps should provide sanitary facilities, including septic tanks and chlorination where necessary.

B. Septic tanks are to be cleaned by pumping and dry land disposal of sludge rather than flushing these tanks to the waterway.

C. Yarding logs across small streams should be carried out with due consideration to the damage caused to downstream water users.

Oils and Like Material

1. "Oil" refers to the following: (a) Oils used for heating or power production; (b) oils used for lubrication; (c) oil emulsions used for cutting or cooling purposes; (d) petroleum cleaning fluids; (e) any other petroleum or asphaltic base compounds.

Oils and Like Material (Continued)

2. Ships, Cargo and Passenger -

A. Bilge or ballast water, waste, or other material containing oil in any amount whatever shall not be dumped or otherwise allowed to discharge from cargo or passenger ships into the waters of the State.

B. When transferring oil, ship-to-wharf connections shall be such as to prevent leakage and the discharge of oil into the waters. Every precaution shall be taken to prevent accidental spills from either ship or shore facilities and to hold and recover such spills as may occur. Drip pans shall be provided for use at hose connections when connecting hoses, during pumping operations, and whenever leakage in any amount is present.

3. Oil Transportation Equipment -

A. Tankers, railroad tank cars, tank trucks, or other facilities used for the loading, unloading, storage, and transportation of oil shall be equipped for the collection of the drip from hose or other connections and the excess oil contained in hose and pipe lines, wherever there is a possibility that this oil will find its way, either directly or indirectly, into a body of water. Provision shall be made, also, for catching accidental spills, and these facilities shall be of such a capacity as to hold the maximum quantity of oil possible from any one spill.

Oils and Like Material (Continued)

B. All valves used for control of oil spills from tank farms, loading racks or other equipment shall be kept closed, except when drainage therefrom is to an approved oil separator.

C. Roundhouses shall be provided for the collection of all oil and oil-and-water mixtures and an adequate separator shall be installed for the separation and recovery of both light and heavy oils from these mixtures. These separators shall be operated in such a manner as to assure their maximum efficiency.

4. Industry - All waste oils and lubricants from industrial operations shall be collected in containers for proper disposal. Oil emulsions used for machine cutting and tool cutting should be collected, treated, and reused wherever possible. In event that these emulsions are discarded, the emulsion must be broken down and the oil recovered for proper disposal. The general wastes from processes, if they contain oil in any amount, must be first passed through an adequate and well-operated oil separator before being discharged into the waters of the State.

5. Service Stations - Service stations with direct outlets to a body of water shall not discard oil to that water or so dispose of it in such a manner that it will be washed into the waters by run-off.

6. Municipal Sewers - Officials of cities, towns, and sewer districts are directly responsible for the control of oil discharged from their respective sewerage systems. Ordinances should be passed which make it unlawful to dump or otherwise discharge oil into the sewer systems.

Oils and Like Material (Continued)

7. Disposal of Oil - Because it is usually desirable to dispose of waste or recovered oil by burning, this should be accomplished with due regard to local or other regulations and without the production of nuisances or hazards. The location of disposal points shall be such as to eliminate any possible pollution of either surface or underground waters.

8. Immediate Action - Immediate steps shall be taken in case of an accidental spill to prevent the spread of the oil and to remove it from the water surface as completely as possible. (For large spills, booms of logs have been used to keep the oil from spreading. The oil may then be pumped from the water surface. Oil resulting from small spills and that remaining after pumping the larger spill can be removed by the use of old burlap, matting, or sawdust. These materials are then burned.)

9. Reports - In case of an accidental oil spill of an appreciable magnitude the party responsible shall make a full and complete written report within 3 days to the appropriate State water pollution control agency. This report shall include the reasons for the accident and the provisions to be taken to prevent its recurrence.

Tanneries

1. A screen will be provided for the wastes from the beamhouse and all hair and fleshings will be removed and disposed of in a satisfactory manner. As a rule 1/8-in. round openings will be satisfactory for the screen for this purpose.

Tanneries (Continued)

2. Lime sludge will be removed in as dry a manner as possible. If the lime is flushed out of the vats, ponds or settling tanks will be provided for the removal of the major portion of the lime from the wastes before it is discharged. In some cases, the water which collects above the lime sludge in the vats can be removed and the lime either shovelled or pumped to land or to ponds.

3. If the tannery uses vegetable tan liquors, this liquor should be mixed with the beamhouse wastes and settled in a pond or tank before the waste is discharged. Under some conditions it may be allowable to store the liquor in a tank and discharge it over a long period of time. It should never be discharged in a batch.

4. It is desirable under most conditions where chrome liquors are used for tanning to also mix these liquors with beamhouse waste and settle either in a pond or tank before discharging to a waterway.

Beet Sugar Factories

1. An effective screen shall be provided for the factory and process waste from the manufacture of beet sugar. The screenings will be removed and disposed of on land or in any other satisfactory manner. It is suggested that the slot openings of the screen be 1/8-in. by 3/4-in.

2. Steffens waste shall never be discharged to a State waterway. This waste must either be evaporated or ponded. In the latter case, it will be necessary to make arrangements with the appropriate State water

Beet Sugar Factories (Continued)

pollution control agency for the discharge of the ponded waste under controlled conditions, and during high-water periods.

3. Settling ponds shall be used for the removal of settleable material from factory and process waste. It is suggested that short-period ponds, constructed to operate in parallel, are more effective than large ponds operated in series. Certain of these ponds will be used until the material which settles starts to decompose. The waste will then be directed to other ponds.

Coal Washeries

1. Effective ponds will be provided for the removal of fine coal and dust before the wash waters are discharged to a stream. The detention period in the ponds will be as long as is possible, and will be established by agreement with the appropriate State water pollution control agency.

Gravel Washeries

1. Effective ponds will be provided for the removal of sand and silt from gravel washings before the wash water is discharged to a waterway. The detention period will be as long as is possible and will be established by agreement with the appropriate State water pollution control agency.

Flax Processing

1. The waste from the processing of flax will be impounded and discharged at high stream flows and under conditions controlled by the appropriate State water pollution control agency.

Dehydration, Potatoes and Fruits

1. In cases where the skins of the potatoes or fruits are removed by means of abrasive equipment, a screen will be provided for the collection of this material and its removal from the water before discharge.

2. In case lime is used for the removal of skins, the waste from the process shall be ponded and discharged under controlled conditions by agreement with the appropriate State water pollution control agency.

3. Peelings, cores, and rejects shall be removed in as dry a condition as possible and disposed of in such a manner as not to enter a waterway.

Metal Industry

1. The wastes from metal industries shall be corrected to a pH value within the limits of 6.0 and 9.0.

2. A concentration of toxic material will be regulated to come below the tolerance of aquatic life to those materials. For instance, in the case of cyanides, the concentration shall not be above 0.5 p.p.m. as KCN. In the case of chlorine, the concentrations shall not be above 1.0 p.p.m. Other tolerance limits for the metals, fluorides, etc., will be established at a later date.

Pulp and Paper Mills

Because of the size and seriousness of the sulfite waste liquor problem, regulations concerning the disposal of this waste will be handled in a separate item and will not be included in this statement of minimum requirements. The following minimum regulations apply to the formation of the pulp sheet and to paper and board production:

1. Provision shall be made either by the installation of effective save-alls and/or by closing, or partially closing, the white-water system to reduce the fiber loss from beater and machine operations to 1 per cent of production.

2. Bark and knotty rejects shall be kept entirely out of State waters.

Reproduced from best available copy.

* * * * * * * * * * *

RECOMMENDED

SEWAGE WORKS DESIGN STANDARDS

POLLUTION CONTROL COUNCIL

PACIFIC NORTHWEST BASIN

by:

Committee on Sewage Works Design Standards

Emil Jensen, Chairman
W. W. Bergerson, Member
Amos J. Alter, Member

September 1952

September 18, 1952

Mr. H. C. Clare, Chairman
Pollution Control Council
Pacific Northwest Area
C/o State Department of Health
Boise, Idaho

Dear Mr. Clare:

Your Committee on Standards for the Treatment of Municipal Wastes hereby submits a final report titled, "Recommended Sewage Works Design Standards".

We wish to especially acknowledge the assistance derived from the Standards for Sewage Works of the Upper Mississippi River, Board of Public Health Engineers; Great Lakes Board of Public Health Engineers; and the Oregon State Sanitary Authority. We also wish to acknowledge the contributions of James Wark of the Washington State Pollution Control Commission and Robert McGrath of the U. S. Public Health Service, River Basins Office.

We recommend that consulting engineers and others having occasion to use these Standards be encouraged to submit constructive criticism; and that the Standards be periodically reviewed and revised.

We wish to direct special attention to the aims and objectives of these Standards as explained in the following "Introduction".

Respectfully yours,

COMMITTEE ON STANDARDS
FOR TREATMENT OF
MUNICIPAL WASTES

Wallace W. Bergerson

Wallace W. Bergerson

Amos J. Alter

Amos J. Alter

Emil C. Jensen

Emil C. Jensen, Chairman

INDEX

	Page
Members of Pollution Control Council	I
PART I -- INTRODUCTION	1-2
PART II -- DEFINITIONS	3-4
PART III -- ENGINEERING REPORT	5-11
Purpose of Report	5
Scope of Report	5
Statement of Problem	5
Present and Future Areas to Be Served	6
Population Forecast for Basis of Design	6
Existing Sewage and Waterworks	6
Garbage Disposal	6
Character and Quantity of Sewage	6
Character and Volumes of Industrial Wastes	7
Degree of Treatment	7
Type of Treatment	8
Sites	9
Basis of Design	10
Necessary Maps and Layout Sketches	10
Soil Conditions	10
Estimates of Construction Costs	11
Estimates of Operating Costs	11
Financing	11
Engineer's Recommendations and Summary	11

INDEX (CONTINUED)

	Page
PART IV -- FINAL PLANS AND SPECIFICATIONS	12-16
Plans	12
General	12
Sewerage Systems	13
Sewage Treatment Works	15
Specifications	16
Sewerage Systems	16
Sewage Treatment Works	17
PART V -- DESIGN STANDARDS - SEWERAGE SYSTEMS	18-25
Sewers	18-23
General	18
Type of Sewer	18
Capacity	18
Minimum Diameter	18
Minimum Grade	19
Location	20
Material	20
Minimum Depth	20
Alignment	21
Manholes	21
Sewer Joints and Infiltration	22
Inverted Siphons	22
Branches and Special Pipes	22
Automatic Flush Tanks	23
High Velocity Protection	23
Overflow Structures	23

INDEX (CONTINUED)

	Page
PART V -- DESIGN STANDARDS - SEWERAGE SYSTEMS (Continued)	
Sewage Pumping Stations	23-26
General	24
Type	24
Number of Pumps	24
Type of Pumps	24
Pump Connections	24
Pump Capacities	25
Wet Well Capacity	25
Construction	25
Cross-Connections	25
Controls	26
Overflows	26
PART VI -- DESIGN STANDARDS - SEWAGE TREATMENT WORKS	27-64
General Items	27-31
Preliminary Treatment Units	31-35
Sedimentation Units	35-41
Sludge Digestion and Disposal Units	41-51
Trickling Filters	51-57
Activated Sludge	58-61
Intermittent Sand Filter	61-62
Disinfection and Odor Control	63-64

I

MEMBERS OF POLLUTION CONTROL COUNCIL

PACIFIC NORTHWEST AREA

Alaska

A. J. Alter, Director
Div. of Sanitation & Engineering
Territorial Department of Health
Juneau, Alaska

Idaho

H. C. Clare, Director
Public Health Engineering
State Department of Public Health
Boise, Idaho

Oregon

C.M. Everts,Jr., Sec. & Chief Engr.
Oregon State Sanitary Authority
Portland, Oregon

Montana

**C. W. Brinck, Director
Div. of Sanitary Engineering
State Board of Health
Helena, Montana

British Columbia

*Reginald Bowering, Director
Div. of Public Health Engineering
Department of Health and Welfare
Victoria, British Columbia

Canada

A. H. Perry, Supervising Engineer
Public Health Engineering Div.
Dept. of National Health & Welfare
Vancouver, British Columbia

Washington

Emil C. Jensen, Chief
Div. of Public Health Engineering
Washington State Dept. of Health
Seattle, Washington

E. F. Eldridge, Director & Chief Engr.
Washington Pollution Control Commission
Olympia, Washington

United States

R. R. Harris, Sr. Sanitary Engineer
Division of Water Pollution Control
Public Health Service
Federal Security Agency
Portland, Oregon

---

* Mr. Norman Goode represented British Columbia during Mr. Bowering's assignment in Korea during 1951.

** Mr. H. B. Foote represented Montana from January 1949 to September 1951.

PART I -- INTRODUCTION

The sewage collection and treatment works is an integral and very important link in a total pollution control program. Therefore, if we are to reach the overall objective, such facilities must be of adequate capacity, capable of providing a sufficient degree of treatment and economical to construct and operate.

This bulletin has been prepared by the Pollution Control Council, representing all State Pollution Control Agencies in the Pacific Northwest area. Its aim is to acquaint engineers engaged in the design, construction, and operation of sewage works with the details given particular consideration when plans are submitted for review and approval. The statements offered are not intended as regulations, since it is fully appreciated that every problem requires individual study and considerable exercise of judgment by the engineer. Neither is it intended that progress in the development of new sewage treatment methods and equipment be stifled; although, experimentation at the risk and expense of any municipality obviously must be prevented.

The bulletin sets forth opinions as to current approved practice and suggestions regarding many of the details of design. Experience with many operating plants through frequent inspections, monthly reports, and contacts with operation personnel places the Pollution Control Agencies in an excellent position to observe and study nearly all types of construction and equipment. By this

bulletin it is hoped to bring about avoidance of past mistakes and to take advantage of proven devices which are known to be satisfactory.

The submission of plans and specifications for review and approval by the Pollution Control Agencies is required to insure that the proposed construction will fit in with long range programs for protection and development of the water resources of entire drainage basins.

A well designed and efficient sewage treatment works reflects credit to everyone participating in the design, construction, and operation. If this bulletin aids in the provision of such facilities, its purpose will be realized.

PART II -- DEFINITIONS

The following list of words and terms used commonly throughout the standards conform with definitions contained in the "Glossary, Water and Sewage Control Engineering" prepared by the Joint Committee representing APHA, PWWA, ASCE and FSWA. For the definitions of other words or terms used, please refer directly to the "Glossary".

Sewage Works -- A comprehensive term which includes facilities for collecting, pumping, treating, and disposing of sewage; the sewerage system and the sewage treatment works.

Sewage Treatment Works -- An arrangement of devices and structures for treating sewage, industrial wastes, and sludge. Sometimes used as synonymous with sewage treatment plant.

Sewerage System -- A system of sewers and appurtenances for the collection, transportation, and pumping of sewage and industrial wastes.

Sewer -- A pipe or conduit, generally closed, but normally not flowing full, for carrying sewage and other waste liquids.

Pumping Station -- A station housing relatively large water pumps or sewage pumps, and their appurtenances. Pump house is the usual term for small water pumps.

Pipe Outlet -- A pipe line which conveys the effluent from a reservoir, sewage treatment plant, or other structure to its point of discharge.

Sewer Outlet -- The point of final discharge of sewage or treatment plant effluent.

Head Wall -- A wall at the end of a culvert or drain to protect fill from scouring or undermining, to increase hydraulic efficiency of the conduit, or to divert direction of flow, to retard disjointing of short sectional pipe, or to serve as a retaining wall.

B.O.D. (Standard) -- Biochemical oxygen demand as determined under standard laboratory procedure for 5 days at 20° C., usually expressed in parts per million.

Sewage Disposal -- The act of disposing of sewage by any method. The term is not synonymous with sewage treatment. Common methods of disposal are Dispersion; Dilution; Farming; Broad Irrigation; Privies; Cesspools.

Receiving Body of Water -- A natural watercourse, lake, or ocean into which treated or untreated sewage or industrial waste is discharged.

Separate Sanitary Sewer -- A sewer which carries sewage and to which storm, surface and ground waters are not intentionally admitted.

Combined Sewer -- A sewer receiving both surface runoff and sewage.

PART III -- ENGINEERING REPORT

The development of a sound and economical plan for a sewage works project will require a thorough preliminary study. It should evidence need for the project, what it will accomplish, and alternatives available. It must be based on extensive field surveys and careful consideration of other factors which may influence the design or construction. The summary of this study is referred to as the "Engineering Report."

This report should be submitted to the Pollution Control Agency for approval prior to preparation of final plans and specifications. Agreement at this point between the designing engineer and the Pollution Control Agency, regarding the type of treatment to be employed and the basis of design to be used, will largely eliminate necessity of revision of detailed plans later. Engineers are encouraged to submit reports and plans in person to the Pollution Control Agency; however, this does not mean that an oral report can be substituted for a written one.

SCOPE OF REPORT

The engineering report should include coverage of all the following items together with any other relevant data pertaining to unusual problems.

1. Statement of Problem

Describe the purpose and need for the proposed project.

2. Present and Future Areas to be Served

Describe the nature and extent of the area included in the present system and the area and extent to which plans provide sewage works for future development. If the area to be served by existing and proposed sewers does not include the entire municipality, sewer district, or natural drainage area, give a brief description of that portion not included, together with information as to the probability of future development, and the method by which this area can be served.

3. Population Forecast for Basis of Design

Discuss the population trend as indicated by available records, and give the estimated future population for the design period. Describe briefly the method used to determine future population trends.

4. Existing Sewage and Water Works

Discuss any existing sewage works as they are related to the proposed project. Discuss the location of water supply and distribution structures as they relate to the various portions of the proposed sewage works.

5. Garbage Disposal

Discuss the considerations given to possibility of garbage disposal in sewage works.

6. Character and Quantity of Sewage

Where there is an existing sewerage system, data on the volume and strength of sewage should accompany the report. These data should be obtained from actual measurements made of both wet weather and dry

weather flows. The laboratory analyses should be made on 24-hour composite samples, and data must cover a sufficient period of time to be representative of actual conditions. It is recommended that the designing engineer confer with the reviewing agency for details concerning the collection and analyses of samples.

In case of new sewerage systems where flows cannot be measured, consideration should be given to water consumption data and information on quantities and strength from other cities with similar conditions. Allowance should be made for ground water infiltration.

7. Character and Volumes of Industrial Waste

List all establishments producing appreciable quantities of industrial wastes and give quantity, production periods, and character of industrial wastes insofar as they may affect the sewerage system or sewage treatment works. Consideration should be given to future industrial expansion.

Quantity and character of wastes should be based on flow gauging and laboratory analyses of composite samples. Sampling periods should be long enough to represent the day's operation and should not be less than 6 hours in duration, covering the period of maximum flow.

8. Degree of Treatment

In general the degree of treatment required should be based upon the size, usage and character of the receiving body of water and upon the amount and strength of sewage or waste to be treated.

In order to remove settleable solids and prevent the formation of sludge banks immediately below the sewer outlet, at least primary treatment should be required in any case, regardless of the size and character of the receiving body of water.

The consulting engineer should consult with the pollution control agency on the degree of treatment before preparation of the Engineering Report.

An approximation of the overall removals to be expected from various types of treatment processes for domestic sewage is given in the following tabulation:

	Approximate Percentage Overall Removal	
	B.O.D.	Suspended Solids
Primary Treatment (Plain Sedimentation)	25-40	40-70
Chemical Precipitation	50-75	70-90
Conventional Rate Trickling Filter	80-95	80-90
High Capacity Trickling Filter:		
Single-Stage	60-85	
Two-Stage	80-95	
Activated Sludge	85-95	85-95
Intermittent Sand Filter	90-95	85-95

9. Type of Treatment

The type of treatment process employed should in each case be based upon the character of sewage or waste to be handled and the degree of treatment required. Consideration should also be given to the cost of installation and operation, the amount of supervision

and maintenance required for proper operation, and the topography and isolation of the plant site.

New processes, methods and equipment: The policy of the pollution control agency is to encourage rather than obstruct the development of new methods and equipment for the treatment of sewage. Any new developments should have been thoroughly tested in full-scale installations, under competent and impartial supervision, before approval of a plant utilizing this process or equipment can be issued, unless the municipality is amply protected by a performance bond, so that in case of failure any expenditure of public money will be refunded. Where it may be necessary to revise or rebuild permanent plant structures in order to accommodate other mechanical equipment after the original installation has been rejected, the performance bond should include provisions to cover the cost of the alterations.

10. Sites

Considerable care should be taken in the selection of a suitable site for the sewage or waste treatment plant. The topography of the land and location of the receiving body of water will, of course, determine to a great extent the possible location. Wherever possible, the site should be comparatively well isolated, particularly with regards to the proximity to residential developments. If isolated sites are not available, it may be necessary to make special provision for controlling objectionable plant odors. Consideration should be given to the direction of the prevailing winds. The plant site should be accessible at all times and should be protected

against flooding. Sufficient area should be available for convenient arrangement of the treatment units and for future expansion of the plant.

Discuss the various sites available and the advantages of the one to be recommended. Indicate the proximity of residences of developed areas to any treatment works. Discuss the relationship of maximum high water to the plant site and various plant units.

11. Basis of Design

a. Give data on design flows for sewers, and ratio of interception in connection with existing combined sewers.

b. State basis of design of each unit of the treatment works. Indicate provision for future needs.

c. Design should comply with standards as set forth under Parts V and VI.

12. Necessary Maps and Layout Sketches

Maps and drawings in sufficient detail to indicate the scope of the project should be included.

13. Soil Conditions

State probably character of soil or strata through which the sewers are to be laid and describe portion of the system that will be below normal ground water level. Indicate any unusual soil or foundation conditions at the site of any sewage works structures, the extent of soil investigations, and outline findings as they relate to probable construction problems or as they may affect portions of the construction.

14. Estimates of Construction Costs

Give estimated cost of integral parts of the system for the contemplated installation.

15. Estimate of Operating Costs

Allowances should be made for power, maintenance, supplies, administrative costs, billing, labor and supervision.

16. Financing

It is not expected that the engineer will supply the complete financing program for the municipality; however, sufficient information should be presented on rates, assessments and charges to industry in order to determine its ability to proceed with the proposed construction.

17. Engineer's Recommendations and Summary

Summarize the report in terms of its overall intent in sufficient detail to permit the owner or municipality to evaluate the different proposals and make such decisions as may be required.

PART IV -- FINAL PLANS AND SPECIFICATIONS

The final plans and specifications should be prepared in conformance with the Engineering Report as approved and the related provisions of Part V -- Sewerage Systems, and Part VI -- Sewage Treatment Works.

PLANS

General

1. Time for submission -- All final plans for construction of new sewerage systems, sewage treatment works, or modifications or extensions of existing sewage works, should be submitted to the pollution control agency at least 20 days prior to date of invitation for bids or other arrangements for proceeding with construction.
2. Approval limitation -- Plan approval by the pollution control agency will cover, principally, the adequacy of the design as it relates to pollution control. It does not include structural design adequacies.
3. Type -- The final plans submitted should be blue prints, black or color line prints or other reproductions of equal quality.
4. Content -- The prints should be legible and should be sufficiently detailed for correct interpretation. Each plan sheet should contain a title, the owner's name, engineer's seal, date, and where applicable a north point.
5. Size -- Plans should be prepared in sheet sizes convenient for filing.

6. As Constructed Drawings -- Upon completion of construction of any sewerage system or sewage treatment works, one complete set of as constructed plans and specifications should be made available to the owner and the pollution control agency, and copies of the sewage treatment works plan and flow diagrams should be posted in the control building, or other convenient location for the benefit of the operator.

Sewerage Systems

Each set of plans submitted for approval, of new, or modified, or extended sewerage systems should include a general layout map, and, where applicable, detailed plans for sewers, sewer profiles, sewer appurtenances and pumping stations.

1. General Layout -- Each set of plans should include a general layout map showing the location of the proposed construction with its relation to existing facilities. In particular the layout map should include the following:
   a. Boundaries: The boundary line of the municipality, or sewer district, to be sewered.
   b. Existing Sewers: The location, size, direction of flow and lengths of all existing sanitary or combined sewers; and the location of all manholes if they relate to the proposed project.
   c. Proposed Sewers: The location, size, direction of flow and the lengths of proposed sewers; and location of manholes.

d. Existing Pumping Stations: Location drawings of all existing pumping stations, properly located in relationship to other sewerage facilities.

e. Proposed Pumping Stations: Location drawings of all proposed sewage pumping stations properly located in relation to existing sewerage facilities.

f. Topography and elevation: Topography, including existing or proposed streets. Pertinent ground elevations should be shown.

g. Streams, Lakes, and Bodies of Water: The direction of flow in all streams and high and low water elevations of all water surfaces at sewer outlets and overflows should be shown.

h. Public Water Supplies: The location of wells, or other sources of public and semi-public water supply, water treatment plants, reservoirs or other structures of public health significance.

2. Sewer Plans -- Each set of sewer plans should include the following details:

a. Adjacent street and property lines.

b. Exact location of sewers in street.

c. Exact location of manholes and other appurtenances. Each manhole should be numbered.

d. Location of watercourses, railroad crossings, water lines, gas lines or other obstructions to be crossed.

3. Sewer Profiles -- Each set of plans should include sewer profiles showing the following details:

a. Profile of ground surface and sewer.

b. Approximate scale drawing of manholes and other appurtenances with each manhole numbered as in (2-c) above.

c. Size, slope and length of sewer between consecutive manholes.

d. Elevation of ground and sewer inverts at each manhole.

e. Elevation of underground structures such as water lines, gas mains, etc., to be crossed.

4. Sewer Appurtenances -- Detailed drawings of manholes, inverted siphons, head walls, stormwater diversions or any other structural work differing from ordinary sewer construction, should be included with each set of plans.

5. Pumping Stations -- Detailed drawings showing plan view, elevations and sections of all pumping stations should be included in each set of plans.

Sewage Treatment Works

Each set of plans submitted for approval of new or modified sewage treatment works should include a general layout map, and detailed construction plans including a sewage flow diagram.

1. General Layout -- This map should include a plat of the plant site with the location of treatment plant and pipe outlet to the receiving body of water shown. A layout plan, showing general arrangement of treatment plant units and areas reserved for future expansion, should also be included on this map.

2. Detailed Plans -- The following should be included in the detailed plans:

   a. A plan view, elevation and sectional views of all treatment plant units.

   b. Details of equipment sufficient to determine operation of the unit.

   c. Plan of piping of all treatment units.

   d. Sewage flow diagram in plan and elevation.

   e. Diagrammatic layout of sludge digester, heating, and gas collection systems.

   f. Plans and profile of the pipe outlet including the head wall, and showing the high and low water levels of the receiving body of water.

SPECIFICATIONS

Detailed specifications covering the proposed construction should be included along with the plans submitted for approval.

Sewerage Systems

These specifications should include complete details to cover pipe material, excavation, laying of sewer pipe, jointing, backfilling, construction of appurtenances and construction of pumping stations. Where high ground water tables are prevalent, limitations on the amounts of infiltration for various pipe sizes should be provided.

Sewage Treatment Works

These specifications should include complete details to cover the construction of all units of the treatment plant including the pipe outlet, and in addition the following requirements:

1. Installation of Mechanical Equipment -- The installation and initial operation of all mechanical equipment should be supervised by a representative of the manufacturer.
2. Operating Equipment -- Specifications should include a complete outfit of tools and accessories for the plant operator's use, such as squeegees, wrenches, valve keys, rake, shovel, etc. A portable pump is desirable.
3. Laboratory Equipment -- A list of the laboratory equipment to be provided should be included.

PART V -- DESIGN STANDARDS -- SEWERAGE SYSTEMS

Plans and specifications for sewerage systems are included under Part IV. Following are recommended design standards.

SEWERS

General

Sanitary sewers should be designed to remove the domestic sewage and basement drainage from houses, business buildings and other public and private establishments, but not the street or roof drainage. They may be designed to remove certain industrial wastes; however, cooling waters should be kept out of sanitary sewers.

Type of Sewer

All new systems and extensions of systems should be designed on the basis of separate sanitary sewers.

Capacity

Sewerage systems should be designed for the estimated tributary population up to 50 years hence, except in considering parts of systems that can be readily increased in capacity. Consideration should be given to anticipated industrial loads, and an allowance made for infiltration in arriving at the design flow.

Minimum Diameter

All public sanitary sewers should be at least 8 inches in diameter.

Minimum Grade

All sanitary sewers should be laid on a grade which will produce a mean velocity, when flowing full or half full, of at least 2 feet per second. Values of the Kutter formula coefficient of roughness, "N" = 0.013, should be used for 2 to 4 foot lengths of pipe. Special consideration should be given to a lower value of "N", in instances where it can be demonstrated that materials and construction will provide better flow characteristics. The minimum grade for various sizes of pipe with an "N" value of 0.013 are as follows:

Inside Pipe Diameter (Inches)	Grade (Feet per 100 feet)
8	0.40
10	0.28
12	0.22
15	0.15
18	0.12
21	0.10
24	0.08
27	0.07
30	0.06

Under special conditions, if full and justifiable reasons are given, slopes slightly less than those required for the 2 feet per second velocity when full may be permitted. Such decreased slopes will only be considered where the depth of flow will be 0.3 of the diameter or greater for design average flow. Whenever such decreased slopes are selected the engineer must furnish with his report his computations of the depths of flow in such pipes at minimum, average, and peak rates of flow.

Pipe outlets carrying only clarified sewage may be constructed at grades below the above minimums.

Location

Sewers located in the vicinity of public water supply wells or other sources or structures should be constructed in conformance with regulations governing public water supplies. Sanitary sewers and domestic water lines should not be laid in the same trench. Parallel water and sewer lines wherever possible should be laid at least 10 feet apart horizontally. Wherever it is necessary for sewer and water lines to cross each other, the crossing should be at an angle of approximately 90° and the sewer should be located 3 or more feet below the water line or be constructed of cast iron pipe with water tight joints, or equal construction, for a distance of 10 feet on both sides of the water lines.

Material

Any generally accepted material for sewers should be given consideration, but the material selected should be adapted to local conditions, special consideration being given to the character of industrial wastes, possibilities of septicity, exceptionally heavy external loadings, abrasion, the necessity for reducing the number of joints, soft foundations and similar problems.

Minimum Depth

All sewers should be laid at depths sufficient to drain basements and to be protected against damage by frost and traffic. Where for specific reasons shallow depths are necessary, and can be justified, the sewer should be protected to prevent its being damaged by frost or traffic. Sewer laid in deep or excessively wide trenches

should be suitably reinforced to prevent damage.

Alignment

Sewer lines should be laid on straight alignment and uniform grade between consecutive manholes.

Manholes

Manholes are mainly for the purpose of facilitating maintenance and operation of sewer systems, and for this reason should be designed, constructed and located as follows:

1. Minimum inside diameter 42 inches or 4 feet by 3 feet oval-shaped.
2. Minimum cover opening, diameter 20 inches.
3. Constructed of materials to make as water tight as possible.
4. Invert should be lined with half tile or molded to conform to sewer cross-section and laid on a grade at least as great as that of the inlet sewer.
5. Drop manholes should be provided for lateral sewers entering a manhole at an elevation of 30 inches or more above the manhole invert.
6. Manholes should be located at every change in grade, size or alignment of sewer, at each intersection or junction of sewer, and at upper end of all lateral sewers.
7. Distances between manholes should not exceed 400 feet on sewer lines 15 inches and less in size, and 500 feet for 18 inches or larger sizes.
8. Lampholes may be permitted as a substitute for manholes on the ends of laterals 150 feet or less in length.

9. All manhole rungs or steps should be not less than 12 inches, or more than 15 inches, apart. Their minimum width should be 9 inches and they should be designed to prevent the foot from slipping sideways. Adequate clearance should be provided between the wall of the manhole and the rungs to afford a secure toehold.

Sewer Joints and Infiltration

The method of making sewer joints and the materials used should be included in the specifications. Packing material and joint compounds which have been demonstrated to minimize infiltration, should be used in bell and spigot pipe joints. Joints should be so constructed as to limit the amount of infiltration to not more than 10,000 gallons per mile per day for systems containing pipe sizes up to 15 inches. Special consideration may be given to leakage allowances for larger size pipes.

Inverted Siphons

Inverted siphons should be designed of such size and grade to maintain a velocity of at least 3 feet per second under conditions of average dry weather flow. Two or more pipe lines should be provided in order to assure that maximum flows can be carried with one line out of service. Manholes should be provided at both ends of the inverted siphon.

Branches and Special Pipes

Wye branch fittings should be installed and tightly plugged in all lateral sewers to facilitate making connections to side sewers. An accurate record should be kept of the location of every wye branch or special pipe installed in the sewer system.

Automatic Flush Tanks

No automatic flush tanks with direct or underground connection to a potable water supply should be maintained in any sewer system.

High Velocity Protection

In the case of sewers where slope and volume are such that velocities above 12 feet per second are realized at average flow, special consideration should be given to anchoring the pipe and providing against erosion and shock.

Overflow Structures

Backflow prevention devices should be provided whenever flooding of the sewer outlet is possible.

SEWAGE PUMPING STATIONS

General

Sewage pumping stations should be used only where gravity systems are impracticable. When pumping is required at the treatment plant, wherever possible, the settled rather than the raw sewage or waste should be lifted. This arrangement will assist in eliminating excessive variations of flow through the primary settling tank and reduce the possibility of clogging the pumps.

General recommended standards for design of sewage pumping stations are as follows:

Type

All sewage pumping stations should have a wet well for receiving the sewage and a dry well to house the pumping equipment, unless the mechanical equipment is so designed and installed that repairs to any one pump can be made without dewatering the pit or interfering with the operation of the other pump or endangering the men working on the equipment.

Number of Pumps

Every sewage pumping station should be provided with at least 2 pumps and in large main pumping stations 3 or more pumps should be provided.

Type of Pumps

The pumps should be of a type designed especially for pumping sewage and should be set below the high water level of the wet well so as to be self-priming. Unless pumps of a special design to prevent clogging are used, they should be preceded by suitable screening or shredding facilities. Wherever possible, motive power for the pumps should be made available from at least two sources. Pump motors should be protected from flooding and condensation.

Pump Connections

Each pump should have an individual suction line and should be automatically controlled. The pump suction and discharge lines should be equipped with suitable check and gate valves to facilitate repairs and should in no case be less than 4 inches in diameter.

Pump Capacities

In larger pumping stations the pump capacities should be such that, with the larger unit out of service, the remaining units can pump the maximum flow of sewage. Where discharge is directly into the treatment plant, pump capacities should be so selected that one pump will operate almost constantly. The other pumping units should automatically go into operation whenever the flow exceeds the capacity of the first pump.

Wet Well Capacity

Wet wells should be of minimum size consistent with pump capacities and not designed to provide storage in case of power failures.

Construction

Wet and dry wells should be completely separated, with separate entrances to each and stairways or other means of easy access. Adequate ventilation should be provided for both wet and dry wells. The latter should be of sufficient size to accommodate the pumps and other equipment without congestion and its floor should be sloped to a sump equipped with adequate drainage facilities. Where it may be necessary to pump sewage prior to grit removal, special attention should be given to the design and construction of the wet well in order to prevent the accumulation of solids. Pump piping should be designed to provide scouring velocities.

Cross-Connections

Potable water lines should not be directly connected to any sewage pump, suction or discharge line for priming, flushing,

lubricating or for any other purpose. Water-operated sump pumps should not be connected to any potable water supply.

Controls

Liquid level controls should be so located as not to be unduly affected by flows entering the well, or by suction of the pump. Float tubes in dry wells should extend high enough to prevent overflow. Provision should be made in arrangement of controls to automatically alternate the pumps in use wherever possible. Provision should also be made for easy cleaning of float tubes.

Overflows

The elevation of overflows should be set above the maximum high water level in the receiving body of water.

PART VI -- DESIGN STANDARDS -- SEWAGE TREATMENT WORKS

Plans and specifications for sewage treatment works are included under Part IV. Following are recommended design standards.

GENERAL ITEMS

Design Flows

Actual flow measurements and sewage analysis should be used as the basis of design for treatment works to serve existing sewerage systems. (See Sec. 6 and 7 of Part III.) The design flow should be based upon the quantities of domestic sewage, infiltration, industrial wastes, and storm water plus allowance for anticipated growth for at least 20 years.

The rate of flow with respect to design of various units may be based on the average 24-hour flow unless the variations in quantity and character are abnormal throughout the day. Under these conditions a shorter time period should be used in determining rate of flow. Also, whenever recirculation is employed, full allowance must be made for these quantities in determining the rate of flow to the affected units.

Dissolved Oxygen

Where it can be expected that the raw sewage will be devoid of dissolved oxygen, provision should be made for aeration, chlorination, recirculation, or other means of offsetting septic action to avoid development of odor nuisance and to insure proper operation of the plant.

Hydraulic Capacity

Pipes, channels, distributors, weirs, flumes, etc. should be designed hydraulically for peak flows equal to 300 percent of average daily flow.

Measurement of Sewage Flow

To assist in effecting proper operation every sewage and waste treatment plant should have facilities, such as parshall flumes, venturi meters, etc., for measuring the rate of sewage flow. It is recommended that such facilities also include automatic measuring and recording devices.

By-Passes

By-pass lines should be provided to facilitate making repairs to the various treatment plant units; however, the plant should be so arranged and designed that at least primary sedimentation can be effected whenever it is necessary to by-pass part of the plant.

Water Supply Connections

An adequate supply of water under pressure should be available at every treatment plant to aid in the general maintenance of the plant and to encourage good operation and cleanliness. Hydrants should be located such that all units of the plant can be reached by a hose. No piping or other connection, however, shall exist in any part of the treatment plant which might result in contamination of a water supply used for drinking purposes. Check and gate valves are not considered adequate protection against contamination through cross-connections.

Fences

Every treatment plant should be enclosed with a suitable fence to protect against trespassers.

Laboratory Facilities

Laboratory facilities suitable for controlling operation and determining the operating efficiency of the various treatment units should be provided at every plant. It is suggested that a list of laboratory supplies and equipment be included in the specifications. The plans should include sufficient laboratory space and appurtenances in the control building or other suitable building at the plant. Specific requirements should be obtained from the pollution control agency.

Safety Precautions

To eliminate occupational hazards, the design of sewage treatment plants should incorporate such measures and features as given in Manual of Practice No. 1, Occupational Hazards in Operation of Sewage Works, Federation of Sewage Works Associations (1944).

Emergency Power Facilities

A standby power source should be provided where the temporary discharge of raw or partially treated sewage may endanger the public health or cause serious damage.

Drains

Drains should be provided to dewater each unit. Due consideration should be given to possible development of hydrostatic uplift on dewatered units.

Construction Materials

Due consideration should be given to the selection of materials which are to be used in sewage treatment works, because of the possible presence of hydrogen sulphide and other corrosive gases, grease, oils and similar constituents frequently present in sewage and wastes. This is particularly important in the selection of metals and paint.

Painting

Use of paints containing lead should generally be avoided. In order to facilitate identification of piping, particularly in large plants, it is suggested that the exposed lines have contrasting colors. The following color scheme is recommended for purposes of standardization:

Sludge lines -- brown
Gas lines -- red
Potable water lines -- blue
Chlorine lines -- yellow
Sewage lines -- gray
Compressed air lines -- green
Water lines for heating digesters or buildings -- blue, with a 6-inch red band spaced 30 inches apart.

Conduits

The bottom corner of channels should be filleted. Pockets and corners where solids can accumulate should be eliminated. Suitable gates should be placed in channels to seal off unused sections which might accumulate solids.

Workshop

Adequate floor space, work benches, and storage should be provided for servicing and making repairs on equipment.

Grading and Landscaping

Upon completion of the plant the grounds should be graded and landscaped. Suitable walkways should be provided for access to all units. Where possible, steep slopes should be avoided to prevent erosion. Surface water should not be permitted to drain into any unit. Particular care should be taken to protect trickling filter beds, sludge beds and intermittent sand filters from surface wash.

Sanitary Facilities

Sanitary facilities, such as toilet, shower and lavatory should be provided.

PRELIMINARY TREATMENT UNITS

Screens and Shredders

1. Where required: Bar screens, racks or shredders should be provided in every treatment plant for the protection of pumps and subsequent treatment units. They may be either hand- or mechanically-operated.
2. Location: Screening chambers should not vent into the control building or other enclosed structure; and when located in deep pits, a stairway for easy access and adequate lighting and ventilation should be provided. In large plants where comminuting or shredding devices are provided, coarse bar racks should

precede these units. Careful consideration should be given to possible disturbance of measuring devices and surcharge of the inlet sewer due to backwater from clogged screens.

3. Comminuting devices: Mechanical screens with shredding devices or comminutors are desirable. If used, however, they should either be installed in duplicate or be supplemented by an auxiliary bar screen for emergency use.

4. Bar Spacing: For manually cleaned bar screens or racks, the clear space between bars should be one to two inches. For mechanically cleaned bar screens the clear space may be from 5/8-inch to one inch. The total net area of the clear openings should be such that a velocity of approximately 2 feet per second will be maintained. For ease in cleaning, all hand raked bar screens should have a slope of between 30° and 45° from the horizontal.

5. Screenings: In the case where screenings are not shredded and returned to the sewage flow, ample and convenient provision should be made for their removal from the screen chamber. A rake to fit the bar spacing should be provided. A suitable platform onto which the screenings can be raked should be installed at the top of the screen or rack. Drainage from the platform should be returned to the sewer. Provision for the sanitary disposal of the screenings by burial or incineration should also be made.

Grit Chambers

1 Grit chambers should be provided at all sewage treatment plants.

2. Location: It is recommended that grit chambers be located ahead of pumps and comminuting devices. In such cases, coarse bar screens should be placed ahead of mechanically-cleaned grit chambers.

3. Number of Units: Grit chambers used in plants treating wastes from combined sewers should have duplicate units if hand-cleaned. Single hand-cleaned channels with by-pass are acceptable for sewage treatment plants serving sanitary sewerage systems.

4. Design Factors:

   a. Velocity: Channels should be designed to provide controlled velocities of not less than 1/2 foot per second and as close as possible to one foot per second. Provision should be made to minimize inlet turbulence.

   b. Detention: The detention period should be 20 seconds to one minute. For hand-cleaned chambers ample grit storage should be provided.

   c. Grit washings: All units not providing positive velocity control should include grit washing devices for the further separation of organic and inorganic materials.

   d. Drains: Provision should be made for draining each channel.

   e. Cleaning: Where large volumes of grit are to be handled, it is recommended that consideration be given to use of specially designed grit removal equipment.

5. Grit Removal: Grit chambers located in deep pits should be provided with facilities for hoisting grit to ground level, access by stairway, adequate ventilation and adequate lighting.

6. Grit Disposal: Means for grit disposal should be provided.

Preaeration and Flocculation

1. General: Flocculation of sewage by air or mechanical agitation, with or without chemicals, is worthy of consideration when the raw sewage is strong and when it is desired to increase the solids removal efficiency of sedimentation units. Preareation should be provided if a zero dissolved oxygen content may be expected in the primary clarifier.
2. Arrangement: The design should be such that the sedimentation units can be used with or without the preaeration or flocculation facilities.
3. Detention Period:
   a. Preaeration units for grease separation should have detention periods of a minimum of 20 minutes.
   b. Preaeration units for the purpose of maintaining dissolved oxygen should have a detention period of 5 to 15 minutes.
   c. Flocculation units should have a detention period of at least 30 minutes.
4. Stirring Devices:
   a. Paddles: Paddles should have a peripheral speed of 1-1/2 feet to 2-1/2 feet per second, to prevent deposition of solids.
   b. Mechanical aerators: Mechanical aerators should provide self-cleansing velocities across floor of tanks.

c. Air: Diffused air mix may utilize any of the types of equipment used for activated sludge aeration tanks. The quantity of air should be sufficient to provide self-cleansing velocities. The rate of application of air should be adjustable.

5. Details: Inlet and outlet devices should be designed to insure proper distribution and to prevent short-circuiting. Convenient means should be provided for removing grit and scum.

6. Flash Mix: Provision shall be made for a flash mix of the sewage with the chemical. The detention period provided in the flash mix chamber should be very short, 1/2 to 3 minutes.

SEDIMENTATION UNITS

Tanks with mechanical sludge removal equipment will generally give higher efficiency in removal of solids and will be less likely to produce an odor nuisance.

General Features

1. Inlets and outlets: The inlet and outlet should be so designed and located as to effect uniform, well-distributed horizontal flow throughout the tank, and prevent short circuiting. Provision should be made to prohibit accumulation of floating and settleable solids in the inlet structure. The outlet should consist of a sharp-crested overflow weir which may be either straight-edged or notched, and which should be adjustable for purposes of leveling. It should be preceded by a suitable baffle

to prevent the escape of floating solids into the tank effluent. Weir loading should not exceed 10,000 gallons/lineal foot per day. Special consideration may be given to allowing slightly higher values for units designed for large flows.

2. Length of Flow: The length of flow from inlet baffle to outlet should be at least 10 feet.
3. Scum Removal: Scum removal equipment should be provided ahead of the outlet weirs on all primary settling basins and should be considered for final sedimentation basins following trickling filters. The equipment should be automatic or provide for easy scum removal. The equipment should discharge to a sludge well for pumping to the digester.
4. Sludge Removal: Suitable equipment for transferring the sludge and scum from the sedimentation tanks to the sludge digesters or other units should be provided. (See provisions under Sludge Digestion and Disposal in regard to pumps, piping and sampling requirements.) Provision for continuous sludge removal from final settling basins is encouraged when the sludge is returned to a primary settling basin.
5. Submerged Surfaces: The tops of troughs, beams, and similar construction features which are submerged, shall have a minimum slope of 1.4 vertical to 1 horizontal. The underside of such features should have a slope of 1 to 1, to prevent the accumulation of scum and septic solids.
6. Multiple Tanks: Consideration should be given to the use of multiple units in installations large enough to warrant such, or when the removal of a single unit from service for a short period will result in health hazards or serious damage.

7. Protective and Servicing Facilities: All settling basins shall be adequately equipped to provide easy access for maintenance and for protection to operators. Such features include stairways, walkways, handrails, etc.

8. Housing: In extremely cold climates housing facilities should be considered to cover sedimentation basins.

Mechanically Cleaned Sedimentation Basins

1. Overflow Rates and Detention Periods: In selecting the overflow rates and detention periods and determining the expected B.O.D. and solids removal efficiency, consideration should be given to size and shape of the units, characteristics of the waste, and secondary treatment processes which may follow.

   a. Primary Settling Tanks -- In general, units treating domestic sewage should be designed on a basis of 2 hour detention and 600 to 900 gallons per square foot per day overflow rate (depending on size and shape of unit). It may be expected that these conditions will permit a 35% reduction in B.O.D. and a 60% removal in suspended solids. Other overflow rates and detention periods should be considered to meet special conditions such as dictated by subsequent secondary treatment processes, character of waste, or to adjust the efficiency to meet requirements.

   b. Intermediate Settling Tanks: Overflow rates for intermediate settling tanks shall not exceed 700 to 900 gallons per square

foot per day based on the design flow (depending on size and shape of units).

c. Final Settling Tanks: Overflow rates for final settling tanks, based on design flow, shall not exceed the following:

Type of Treatment	Overflow Rate
Trickling Filters	700-1000
Activated Sludge	800

The higher values may be used in such cases as standard type filters, large sedimentation units or where degree of treatment is not critical.

2. Depth: The depth of mechanically-cleaned sedimentation basins shall be as shallow as practical, but with a minimum side water depth of 6 feet and 8 feet for secondary on activated sludge plants.

3. Hopper Slopes: The minimum slope measured along the diagonal of sludge hoppers shall be 1.4 vertical to 1 horizontal.

Non-Mechanical Sedimentation Basins

1. Inlets: In non-mechanical conical or pyramidal hopper-bottomed sedimentation basins, the inlet should be at least 6 feet below the water surface and 5 feet from the bottom of the hopper. A baffle should be provided for dissipating the velocity of the incoming sewage.

2. Hopper Slopes: Sludge hoppers in non-mechanical sedimentation basins shall have a minimum slope of 1.5 vertical to 1 horizontal, to be measured along the diagonal in pyramidal hoppers.

3. Detention Period and Overflow Rates: Same as for Mechanically cleaned Sedimentation Basins except that removals of 30% B.O.D. and 55% solids may be expected.

Imhoff Tanks

Imhoff tanks may be used for small to medium-sized installations but should not be used for industrial or other wastes which create acid or excessive alkaline conditions. Consideration should be given in the design and location of Imhoff Tanks to the fact that an odor problem is likely to develop.

1. Settling Compartment:
   a. Minimum detention for average daily sewage flow, 2.0 to 2.5 hours, depending on size of installation.
   b. Maximum overflow rate for average daily sewage flow, 600 to 800 gallons per square foot of surface area per day, depending on size of installation.
   c. Inlets and outlets so designed and located as to effect uniform, well-distributed horizontal flow throughout the tank and with suitable baffles to prevent the escape of floating solids into the tank effluent.
   d. Overflow weirs straight-edged and adjustable.
   e. Bottom slopes of 1.4 vertical to 1.0 horizontal.
   f. Width of slot, 8 inches.
   g. Minimum overlap or horizontal projection at slot, 8 inches.
   h. Minimum "freeboard" of 18" from the water surface to the top of the tank.

2. Sludge Compartment:

   a. Minimum sludge storage capacity, 3 cubic feet per capita for primary sludge only; 4 cubic feet per capita for primary sludge plus trickling filter humus. In computing the capacity of the sludge chamber, only that portion below a horizontal plane, 18 inches below the slot in the bottom of the settling compartment is to be considered.

   b. Minimum slope of sludge hopper floor, 1.0 vertical to 1.5 horizontal.

3. Gas Vents: The total gas vent area should be at least 20% of the area of the sludge compartment. One gas vent shall be at least 24 inches wide.

4. Sludge Piping:

   a. Individual draw-off line from each hopper.

   b. Minimum diameter for gravity lines, 8 inches.

   c. Minimum static head for gravity draw-off, 6 feet.

5. Miscellaneous:

   a. Provide walkways and handrails wherever necessary for the safety of the operating personnel and for facilitating daily tank maintenance.

   b. Facilities for reversing the flow may be provided, if desired.

6. Special Operating Equipment: Provision should be made for skimmers, squeegees, slot cleaners, and sludge depth samplers.

Septic Tanks

Septic tanks are not considered satisfactory for municipal treatment works, because of their low efficiency. They should be used only for treating sewage from schools, small institutions, residences, etc. Advice on suitability of a septic tank and design requirements should be obtained from the pollution control agency or local health department.

Other Types

Sedimentation units employing a radical departure from conventional design in regard to flow characteristics or for combining sludge digestion facilities, etc., should be given consideration only where full-scale units have been in operation for a sufficient period of time to provide data concerning the efficiency and operating costs and to assure that mechanical and maintenance problems have been worked out.

SLUDGE DIGESTION AND DISPOSAL UNITS

General Features

1. Multiple units: Multiple digestion tanks are recommended. Where this is not practical, it is desirable to have a lagoon or open tank for emergency use, so that the digester can be taken out of service without unduly interrupting plant operation.
2. Depth: The depth of a digestion tank should be sufficient to allow for the formation of a distinct supernatant zone.

3. Maintenance provisions: To facilitate emptying, cleaning and maintenance, the following features are desirable.

   a. Slope: The digester bottom should slope at least 4" per foot toward the withdrawal piping, unless the tank is provided with sludge collection mechanisms.

   b. Access manholes: At least 2 access manholes should be provided in the top of the digester, in addition to the gas dome. One opening should preferably be large enough to permit the use of mechanical equipment to remove grit and sand.

   c. Safety: Non-sparking tools, safety harness, gas detectors for inflammable and toxic gases, and gas masks of the closed or oxygen-helmet type should be provided.

4. Sludge Inlets: The raw sludge inlet lines should discharge at a distance at least equal to the radius of the tank from the transfer or supernatant drawoff. One inlet should discharge above the liquid level and at approximately the center of the tank, unless mechanical scum breakers are provided. Sludge piping for multiple units should be so arranged that any tank may be used as the primary digestion tank.

5. Sludge Outlets: The sludge drawoff pipe should be placed at the center of the bottom of the tank. In multiple units provision should be made to permit transfer from the upper half of the primary digester as well as from the bottom.

6. Recirculation: Facilities for recirculation of sludge in the

digesters should be provided. The piping should be arranged to permit recirculation from both the bottom and mid-depth.

Capacity

1. Solids Basis: Where the composition of the sewage has been established, digestion tank capacity should be computed from the volume and character of sludge to be digested. Due allowance should be made for sludge storage and supernatant.
2. Population Basis: Where solids data are not available, the following unit capacities should be used for plants treating domestic sewage. The capacities should be increased by allowing for suspended solids population equivalent of any industrial wastes in the sewage, and may be reduced if the sludge is dewatered mechanically. Volume should be calculated on the basis of the bottom having planes, sloping 30° from the horizontal upward from the end of the withdrawal pipe, unless sludge moving equipment is installed.

Type of Plant	Cubic Feet Per Capita	
	Heated	Unheated
Primary	2 to 3	4 to 6
Primary plus standard filters	3 to 4	6 to 8
Primary plus high-rate filter	4 to 5	8 to 10
Primary plus activated sludge	4 to 6	8 to 12

For small populations (5,000 or less) consideration should be given to using the larger values. Additional capacity shall be provided where garbage solids are anticipated.

Gas Collection Piping and Appurtenances

1. General: All portions of the gas system, including the space above the digester liquor, storage facilities and piping, should be so designed that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under pressure. All points where any gas leakage might conceivably occur should be adequately ventilated and separated from areas where extraneous sparks, fires or lights might occur. The use of a common wall between the digester and a control building is not recommended.

2. Safety Equipment: All necessary safety facilities should be incorporated where gas is produced. Pressure and vacuum relief valves are necessary on digester roofs; and flame traps are essential on all lines greater than 1/2" in diameter. Waterseal traps should not be installed. (See provisions of Manual of Practice No. 1, Occupational Hazards in Operation of Sewage Works, FSWA, 1944.)

3. Gas Piping, Sediment and Condensate Traps: Gas piping should be at least 2" in diameter, except in the immediate vicinity of the boiler, and should slope to condensation traps at low points. The first low point should be equipped with a sediment trap. The use of float control condensate traps should not be permitted.

4. Gas Utilization Equipment: Gas burning boilers, engines, etc., should be located at ground level and in well-ventilated rooms. Gas lines to these units shall be provided with suitable flame

traps and a means of regulating the pressure.

5. Electrical Fixtures: Electrical fixtures in enclosed places where gas may escape shall comply with the National Board of Fire Underwriters' specifications for hazardous conditions.

6. Waste Gas: Waste gas burners should be located at least 25 feet away from any plant structure, if placed at ground level, or may be located on the roof of the control building if accessible for maintenance and if sufficiently removed from the digester. Gas lines to the waste gas burner shall include a flame trap and back pressure regulator. Pilot lines shall be 1/2" or less in diameter and provided with a flame check. In remote locations it may be permissible to discharge the gas to the atmosphere through a return bend screened vent, terminating at least 10 feet above the walking surface, provided the assembly incorporates a flame trap.

7. Ventilation: Any underground enclosures connecting with digestors or containing sludge, or gas piping, or equipment, should be provided with forced ventilation, which should be in operation preferably automatically, during occupancy. This might be accomplished by control through the light switch.

8. Meters and Manometers: A gas meter should be provided on the main gas line or on both the boiler and waste gas burner. Manometers should be provided on the main gas line and on the gas piping system at every location downstream from pressure regulators.

Digestor Heating

In order to maintain temperatures suitable for proper digestion of sludge, digestion tanks should be provided with heating facilities. This can be accomplished by means of internal hot water heating systems, external heat exchangers, or by use of live steam, etc.

1. Heat Losses and Insulation: Expected heat losses should be calculated and sufficient insulation provided to insure maintenance of recommended temperatures taking into account available heating capacity and mean temperatures during the coldest month.
2. Heating Capacity: Sufficient heating capacity should be provided to maintain the sludge at 85° to 95° or more at all times.
3. Heating Facilities:
   a. Internal heating coils: Hot water heating coils for heating digesters should be at least 2" in diameter. The coils as well as the support brackets should be cast or wrought iron. The use of dissimilar materials should be avoided to minimize galvanic action. The high point in the coil should be vented to avoid air lock. Sufficient coil radiation surface should be provided to adequately maintain proper operating temperatures within the digester and within the coils. The coils should be preferably of the vertical bank type to permit convenient servicing. An automatic mixing valve should be provided to temper the boiler water with return coil water so that coil inlet water can be held at 140° or less.

b. External heat exchangers: These units should be designed to operate with a water bath temperature of approximately 140° F. The boilers should be equipped to operate automatically on sewage gas only or alternately on sewage gas and an auxiliary fuel. If used in connection with a fixed cover digester, gas storage to the extent of about 10% of the capacity of the digester, should be provided. Provision should be made that the recirculation pump will operate at all times the heat unit is on.

c. Steam: Steam injection systems for high or low pressure boilers should be provided with a check valve and vacuum relief to prevent back siphonage. Steam piping should be insulated and provided with suitable condensate traps at low points. Facilities should be provided so that sewage gas or auxilliary fuel can be burned interchangeably or simultaneously. The quality of water supply for boiler feed water should be given careful consideration.

4. Boiler Controls: The boiler should be provided with suitable automatic controls to maintain proper boiler temperature, to minimize corrosion, or shut off the main gas supply in the event of pilot burner or electrical failure. In addition a high pressure or temperature shutoff and low water shutoff are essential.

5. Thermometers: Thermometers should be provided to indicate temperatures at critical points in the sludge and water or steam piping systems.

Supernatant Withdrawal

1. Piping Size: Supernatant piping should not be less than 6" in diameter.
2. Withdrawal Arrangements:
   a. Withdrawal levels: Piping should be arranged so that withdrawal can be made from 3 or more levels in the tank. A positive unvalved overflow should be provided.
   b. Withdrawal selection: On fixed cover digesters the supernatant withdrawal level should preferably be selected by means of interchangeable extensions at the discharge end of the piping.
3. Provision should be made for returning supernatant liquor to the plant influent.
4. Sampling: Provision should be made for sampling at each supernatant drawoff level. Sampling pipes should be at least 1-1/2" in diameter.
5. Emergency Supernatant Disposal: An emergency disposal method for supernatant liquor in the form of a lagoon or an additional sand bed should be provided for use in case supernatant is not suitable or other conditions make it inadvisable to return the liquor to the plant. In large plants, consideration should be given to supernatant conditioning.

Sludge Pumps and Piping

1. Sludge Pumps:
   a. Capacity: Thorough study should be given to selection of

pump capacities to insure that they are adequate, but not excessive. Excessive capacity will result in ineffective removal from sludge hoppers and waterlogging of digesters. Provision for variable pump capacities is recommended.

b. Duplicate units: Duplicate units should be provided where failure of one unit would seriously hamper plant operation.

c. Type: Positive displacement or specially designed centrifugal pumps incorporating unrestricted clearance, or comminuting features, should be provided for handling raw sludge. Centrifugal pumps may be used for secondary sludge.

d. Minimum Head: A minimum positive head of 24" should be provided at the suction side of centrifugal-type pumps and is desirable for other types of sludge pumps.

e. Sampling Facilities: Sludge sampling facilities should be provided to permit control of sludge pumping operations. It is recommended that provision be made for visual examination of sludge during pumping operations.

2. Sludge Piping:

a. Size and Head: Sludge withdrawal piping should have a minimum diameter of 8" for gravity withdrawal and 6" for suction. Sludge pump discharge piping should be at least 4" in diameter. Where withdrawal is by gravity, the available head on the discharge pipe should be at least 6 feet and preferably more.

b. Drainage: Provision should be made for flushing all sludge lines and draining where freezing may be a factor.

c. Length: All sludge piping should be as short and direct as possible.

Sludge Drying Beds

1. Area: The sludge drying bed area needed for dewatering digested sludge is dependent upon weather conditions. The following per capita areas have been found satisfactory where the average annual rainfall is between 30 and 45 inches. For areas where the average annual rainfall is less than 10 inches, these figures can be reduced by 50%. For areas where the average annual rainfall is between 10 and 30 inches, they may be reduced 25%; and for areas with excessive rainfalls, they should be increased 50 to 100%.

	Area in Square Feet	
Type of Treatment	Open Beds	Covered Beds
Primary	1.5	1.0
Standard and High-Rate Filters	2.0	1.25
Activated Sludge	2.5	1.5
Chemical Precipitation	3.0	2.0

2. Media: The filtering material should be at least 12" deep above the top of the underdrain tile, and should range in size from 3/4 to 1-1/2" in diameter next to the drain tile, to about 1/4" in diameter at the top of the gravel layer. The top 6" should consist of clean, coarse sand.

3. Underdrains: Underdrain tile should be laid with open joints on preferably 10-foot centers, and the drainage should be returned to the plant for further treatment. Joints should be protected to exclude gravel.

4. Number of Units: It is recommended that sludge beds be divided into several units for flexibility of operation. If earth berms are used, they should be stabilized.
5. Sludge Influent: The sludge influent pipe to the beds should terminate at least 12" above the sand surface, and, if possible, be so arranged that it will drain. Concrete splash plates should be provided at sludge discharge points.
6. Sludge Removal: Means should be provided to facilitate removal of dried sludge, such as truck tracks in the bed or overhead trolleys, and access roadways.

Other Sludge Dewatering Facilities

If it is proposed to dewater or dispose of sludge by other methods, a detailed description of the proposed process and design data should accompany the plans.

TRICKLING FILTERS

General Features

1. Applicability: Trickling filters may be used for treatment of sewage and industrial wastes of a type amenable to purification by biological processes. Normally, trickling filters shall be preceded by effective sedimentation tanks equipped with scum collecting devices.
2. Classification: Trickling filters will be classified as "standard rate" or "high-rate" units, on basis of volume of flow per

unit of surface area and biochemical oxygen demand loading per unit of media volume. Generally, standard rate filters are dosed at less than 4 mgad with an applied B.O.D. of less than 0.4 lbs/cu.yd/day. High-rate filters are dosed at 10 to 30 mgad with B.O.D. loading generally in excess of 0.8 lbs./cu.yd./day.

3. Effluent Comparison: The standard rate filters generally produce a higher degree of nitrification than the single or two-stage high-rate filters. Single-stage high-rate filters produce an effluent acceptable only where an intermediate degree of treatment is required. Two-stage high-rate filter installations produce results fairly comparable to those produced by the standard rate filter or the activated sludge process.

4. Design Basis: The organic (B.O.D.) loading and the volume of sewage are the primary factors of concern.

   a. The B.O.D. loading should be that remaining in the sewage flow after primary sedimentation.

   b. The hydraulic loading should include any quantities of recirculation.

5. Dosing Equipment:

   a. The sewage may be distributed over the filter by rotary distributors or other suitable devices.

   b. Dosing: The distribution devices may be actuated by siphons or pumps, or by gravity discharge from preceding treatment plant units, when suitable flow characteristics have been developed.

c. Hydraulics: All hydraulic factors involving proper distribution of the sewage on the filters should be carefully calculated. For reaction-type distributors, a minimum head of 18" between low water level in the siphon chamber or the low point in the clarifier effluent launder and center of arms is desirable.

d. The sewage should be distributed as uniformly as possible and so that at least 90% of the surface area receives sewage directly. The deviation from a calculated uniformly distributed volume per unit area should not exceed 100% on any portion of the filter.

e. Clearance: A minimum clearance between media and distributor arms of 6" should be provided. Greater clearance is essential where icing occurs.

6. Media:

a. Quality: The media should be natural stone, crushed rock or other suitable material. The media shall be resistant to spalling or flaking and be relatively insoluble in sewage. It should have a loss by the 20-cycle sodium sulphate test of less than 10%.

b. Size: It should be of a size that will pass a 4-inch screen and be retained on a 2-inch screen, shall be free from dust, clay, sand or fine material. It should be approximately cubical in shape and free from flat or elongated pieces.

c. Placing Media: The media should be screened or forked at the sewage treatment plant site to remove all fines. The media should be placed in the filter by hand-operated equipment or by belt conveyor, so as to minimize abrasions.

7. Underdrain System:

a. Arrangement: The underdrainage system should cover the entire floor of the filter. Inlet openings into the underdrains at the interface of the rock media and the underdrainage system should have an unsubmerged gross combined area equal to at least 25% of the surface area of the filter.

b. Slope: The underdrains should have a minimum slope of 1%. Effluent channels should be designed to produce a minimum velocity of 2 ft./sec.

c. Flushing: Provision should be made for flushing the underdrains. On small filters, use of peripheral head channels with vertical vents is acceptable for flushing purposes. An inspection gallery is advisable.

d. Ventilation: The underdrainage system effluent channels and effluent pipes should be designed to permit free circulation of air through the filter media by convection; or forced draft ventilation should be provided at the rate of 1 cfm per sq. ft. of filter surface. The size of drains, channels, and pipes should be such that not more than 50% of their cross-sectional area will be submerged under operation of the filter at a rate of 30 mgad.

Standard Rate Filters

1. Efficiency: Expected reductions in biochemical oxygen demand through a standard rate filter and subsequent settling tanks may be determined from the following table.

Standard Rate Filter Performance -- No Recirculation

B.O.D. Loading/day		Percent Removal
Lbs. per 1000 Cu.Ft.	Lbs.per Cu.Yd.	By Filter and Final Clarifier
8	.216	84%
10	.27	82%
12	.325	80%
15	.40	77%

For installations where critical stream conditions may occur, in cold weather, the percentage B.O.D. removal for any given application should be decreased 10% for uncovered and 5% for covered filters.

2. Depth: The filter media shall have a minimum depth of 5 feet above the underdrains.

3. Dosing Interval: The time interval between the application of sewage to the filter at design rate should generally not exceed 5 minutes.

4. Recirculation: The pipe layout should be such as to permit recirculation of filter or final tank effluent to reduce excessive detention periods and extended periods of no application of sewage to the filters. Continuous return of sludge from the sludge hopper in the final settling tank to the primary tank is recommended.

5. Special Features:

   a. Flooding: Consideration should be given to the design of filter structures so that they may be flooded.

   b. Maintenance: All distribution devices, underdrains, channels and pipes should be installed so that they may be properly maintained, flushed or drained.

High-Rate Filters

1. Recirculation: A controlled recirculation system should be provided to maintain continuous dosing at a rate always equal to or in excess of 10 mgad.

2. Distribution: The distribution system should provide continuous discharge onto the filter. The rest period during which any unit area receives no sewage should not be in excess of 15 seconds.

   Following completion of construction of a filter, tests of distribution of flows onto the filter should be made by a series of adjacent pans, consisting of watertight compartments 6" x 12" in plan. These pans should be placed along an entire radius of the filter, with the 12" length perpendicular to that radius. The flow discharged against a 12" section of the filter wall should be drained into the end pan. With arm distributors, the duration of the test shall be any whole number of revolutions; where disc distributors are used, tests should be made along two radii approximately 90° apart. Where feasible, the tops of the pans should be flush with the surface of the filter media.

Results of tests should be reported to the reviewing authority.

3. Intermediate Clarifiers: In two-stage installations an intermediate clarifier should be provided.

4. Flow Measurements: Devices should be provided to permit measurement of flow to filter, or recirculated effluent, whenever recirculation is used.

5. Loadings and Efficiency: The B.O.D. loading (lbs. per unit volume of filter media) below certain maximum limits and within certain volumetric limits, is the prime factor in determining reduction in B.O.D. The strength of the waste (ppm of B.O.D.) applied to the filter to some extent affects the reduction and accordingly provision of recirculation for the purpose of diluting the filter influent is necessary for strong wastes or when high removals are required.

   a. In general, a single stage high-rate filter for treatment of normal domestic sewage may be loaded at the rate of 1.5 to 2.0 lbs. of B.O.D. per cubic yard. At this loading, the combination of the filter and subsequent clarifier may be expected to effect a reduction of 65% in the B.O.D.

   b. Use of other loadings or two-stage filters should be considered in the event industrial wastes are present or where a higher degree of treatment is required. The basis of design for these other conditions should be discussed with the pollution control agency and their confirmation on expected removals obtained prior to preparation of plans or reports.

ACTIVATED SLUDGE

Under normal conditions the activated sludge process will give a high degree of treatment for domestic sewage. Experience has indicated that shock loads must be given special consideration in the design and operation of this type of plant. The activated sludge method employs either diffused (compressed) air or mechanical aeration.

Diffused Air Type

1. Aeration Period: The aeration tank should have sufficient volume to provide a displacement period of from 6.0 to 8.0 hours based on the average daily sewage flow and an additional 25% to accommodate return activated sludge. In case of an exceptionally strong sewage due to industrial wastes, the volumetric capacity of the aeration tanks should be based on 5 cu. ft. per B.O.D. population equivalent of one.
2. Air Blower Capacity: The air compressors, piping and diffusers should have capacity to supply at least 1.5 cu. ft. of free air per gallon of sewage treated. In order to provide for flexibility of air application, two or more compressors should be provided with appropriate capacities and in larger installations one compressor should be equipped for variable speed.
3. Tank Design: Tank depths of 15 feet are common for large plants, with depths of 10 feet sometimes being used for comparatively small installations. Tank widths are usually equal to about twice the depth with a minimum width-length ratio of 1 to 5. Short-circuiting of flow through the center or core of spiral-

flow tanks can be reduced by the installation of transverse baffles. All bottom corners in aeration tanks should be filleted to eliminate low velocity areas. Tanks should be equipped with drain for complete dewatering, wherever possible. Multiple units should be provided where the total volumetric capacity required exceeds 5000 cu. ft.

4. Diffuser Capacity: Diffuser plate and tube area should provide for at least 3 cubic feet of air per square foot per minute at maximum blower capacity. Where jet or aspirator type diffusers are used, manufacturers' specifications should be followed.
5. Return Sludge Units: Where pumps are used for return activated sludge, they should be in duplicate and provided for variable spee for a range of from 10% to 50% sludge return. Pumps should be placed with positive suction head. Air lifts where they can be applied are acceptable and in some cases preferred for sludge return in which case the capacity of the compressor should be increased accordingly.
6. Measuring Devices: Devises for measuring air flow and pressure, and return and excess activated sludge should be provided.

Mechanical Aerator Type

1. Aeration Period: An aeration period of 8.0 to 12.0 hours should be provided based on the average daily sewage flow plus an allowance of 25% for return activated sludge.
2. Tank Design: Channels and openings between aeration tanks should be designed to prevent excessive fluctuations in liquid

surface elevations in the aeration tanks. A minimum of 3 complete turnovers per hour is recommended, depending somewhat upon the strength and character of the sewage.

If more than one aerator tank is to be installed, the design should allow for either series or parallel operation. All bottom corners in flat bottom tanks should be filleted to prevent deposition of sludge. It is recommended that pipe connections to the sludge pump be made so that the aerator tank can be dewatered. Mechanical aerator tanks are generally square or round, with flat or hopper bottoms and with depths ranging from 9 to 19 feet.

3. Return Sludge Units: See provisions under "Diffused Air Type".

4. Measuring Devices: See provisions under "Diffused Air Type".

Final Settling Tanks

In activated sludge plants the overflow velocity at the effluent weirs of the final settling tank should be kept as low as possible because of the light, flocculent character of the sludge. It is recommended that the length of effluent weir be such that the maximum overflow rate will not be greater than 5000 gallons per day per lineal foot of weir. This rate will necessitate the use of "H" weirs in rectangular tanks. These tanks should have the full 2-hour detention period at 800 gallons per square foot per day overflow rate. All beams, troughs or channels which are partially submerged should be sloped on the underside to prevent accumulation of septic solids beneath them. Connecting ports or conduits between aeration

tanks and final settling tanks should be designed for a velocity below 0.5 feet per second to prevent breaking of floc.

Provisions should be made to deliver the excess sludge from the final tank to both the inlet of the primary tank and directly to the sludge digestion tank. Suitable facilities for measuring, apportioning, inspecting and sampling the return and excess sludge should also be provided.

In the mechanical aerator type, combination aerator-clarifier units should not be accepted unless the settled activated sludge is returned directly and positively to the aeration chamber.

INTERMITTENT SAND FILTERS

Intermittent sand filters, if properly operated and maintained, and if not overloaded, can be expected to furnish a fairly high degree of treatment. Their use is limited, however, because of the large area which they require and also because of their comparatively high cost of construction and operation. Operating difficulties can be expected, especially in areas where winters are severe.

Filter Loadings

The loading for intermittent sand filters should not exceed 120,000 gallons per acre per day for settled domestic sewage or 800,000 gallons per acre per day for biologically treated domestic sewage.

Filter Design

1. At least two beds should be provided for flexibility of operation.
2. Suitable underdrains placed on not greater than 10-foot centers should be provided.
3. The total depth of filter media above the underdrains should be not less than 36 inches. The first 6 inches above the underdrains should consist of graded gravel ranging in size from 3/4 to 1-1/2 inches at the bottom to 1/4 inch at the top. At least the upper 24 inches of the bed should consist of clean, washed sand which has an effective size of 0.3 to 0.6 mm. and a uniformity coefficient of not more than 3.5.

Dosing Tank

1. The volume of the dosing tank or siphon chamber should be sufficient to flood the filter bed to a depth of from 2 to 4 inches. The dosing apparatus should have a discharge capacity at minimum head, of at least double the estimated maximum rate of inflow into the dosing tank.
2. Suitable facilities, such as splash plates, troughs or perforated pipes, for distributing the sewage or waste uniformly over the entire surface of the bed are essential for satisfactory operation of intermittent sand filters.

DISINFECTION AND ODOR CONTROL

Chlorination or equally effective disinfection of the sewage treatment plant effluent should be provided wherever and whenever the use of the receiving body of water for domestic water supply, irrigation, shellfish propagation, swimming or other recreational purposes may be detrimentally affected.

General Features

1. Equipment: The use of equipment designed to feed chlorine gas in solution should be provided. Suitable scales and residual testing equipment should be provided.
2. Housing and Location: Suitable housing facilities at or above ground level should be provided. Heating facilities should be installed. If the equipment is to be placed in a building used for other purposes, a tight partition should separate the room housing the equipment from any other portion of the building and the room should be provided with an outside entrance. Adequate ventilation facilities should be installed.
3. Capacity of Chlorinator: Chlorinator capacities required will vary, depending on the use and point of application of the chlorine. For disinfection of other than raw or septic sewage, a capacity of 5 ppm should be adequate. The unit should be equipped to control the residual at not more than 0.5 ppm. For odor control, provision should be made for the application of at least 20 ppm.

4. Mixing: Thorough mixing by baffles or other means should be provided.

5. Contact Period: After thorough mixing, a minimum contact period of 20 minutes at average flow should be provided for disinfection.

POLLUTION CONTROL COUNCIL

PACIFIC NORTHWEST AREA

WATER QUALITY OBJECTIVES

By:

Committee on Water Quality Objectives:

Mr. H. C. Clare, Chairman
Mr. Reginald Bowering, Member
(Replaced by Mr. Gerald T. Orlob)
Dr. A. F. Bartsch, Member
(Replaced by Mr. John N. Wilson)
Mr. C. M. Everts, Jr., Member

1952

TABLE OF CONTENTS

	Page No.
Members of Pollution Control Council	I
Committee's Letter to Council	II
Foreword	1
Statement of Policy	2
Introduction	3
Definitions	3
Conditions Applying to Objectives	3
Chart Showing Water Quality Objectives for Various Water Uses	Following 3

I

MEMBERS OF POLLUTION CONTROL COUNCIL

PACIFIC NORTHWEST AREA

Alaska

A. J. Alter, Director
Div. of Sanitation & Engineering
Territorial Department of Health
Juneau, Alaska

Idaho

H. C. Clare, Director
Public Health Engineering
State Department of Public Health
Boise, Idaho

Oregon

C.M. Everts,Jr., Sec. & Chief Engr.
Oregon State Sanitary Authority
Portland, Oregon

Montana

**C. W. Brinck, Director
Div. of Sanitary Engineering
State Board of Health
Helena, Montana

British Columbia

*Reginald Bowering, Director
Div. of Public Health Engineering
Department of Health and Welfare
Victoria, British Columbia

Canada

A. H. Perry, Supervising Engineer
Public Health Engineering Div.
Dept. of National Health & Welfare
Vancouver, British Columbia

Washington

Emil C. Jensen, Chief
Div. of Public Health Engineering
Washington State Dept. of Health
Seattle, Washington

E. F. Eldridge, Director & Chief Engr.
Washington Pollution Control Commission
Olympia, Washington

United States

R. R. Harris, Sr. Sanitary Engineer
Division of Water Pollution Control
Public Health Service
Federal Security Agency
Portland, Oregon

---

* Mr. Norman Goode represented British Columbia during Mr. Bowering's assignment in Korea during 1951.

** Mr. H. B. Foote represented Montana from January 1949 to September 1951.

September 10, 1952

Members of the Pollution Control Council
Pacific Northwest Area
Office of the Secretary
Portland, Oregon

Gentlemen:

Your committee appointed by the Pollution Control Council, Pacific Northwest Area, to prepare Water Quality Objectives, herewith submits its report. If needs arise and information becomes available, additions can be made to the Water Quality Objectives. Members of the committee besides the chairman, are as follows:

Mr. C. M. Everts, Jr.
Secretary and Chief Engineer
Oregon State Sanitary Authority

Mr. Reginald Bowering, Director
Division of Environmental Sanitation
British Columbia Department of Health
and Welfare

Dr. A. F. Bartsch, Biologist
Drainage Basins Office
U. S. Public Health Service

Mr. Gerald T. Orlob, Survey Engineer, Washington Pollution Control Commission, and Mr. John N. Wilson, Basin Biologist, replaced Mr. Reginald Bowering and Dr. A. F. Bartsch, respectively, on this Committee.

Your committee appreciates the valuable assistance rendered by Council members in the preparation of its report.

Respectfully submitted,

H. C. Clare

H. C. Clare, Chairman
Committee on Water Quality Objectives

HCC:ad

POLLUTION CONTROL COUNCIL
PACIFIC NORTHWEST AREA

WATER QUALITY OBJECTIVES

FOREWORD

The Pacific Northwest is at present in an enviable position as regards its natural resources and potential development when compared with many other areas of this country. This is especially true of natural waters which are admittedly one of the area's greatest assets. Water is so definitely tied in with the health, welfare, and pleasure of citizens, and with the whole economic structure of the area as to make high water quality objectives not only desirable, but imperative.

A similar position was held by many areas of this country during the past years. The development of these areas without regard to the implications of pollution has resulted in many cases in the loss of the waterways and streams for any use except the disposal of sewage and wastes. The water essential to growth and to effective living has been dissipated by carelessness and lack of foresight. Water is a factor which can well limit the development of all areas of the country, and, therefore, water pollution control in the Pacific Northwest becomes a conservation and prevention program. Certainly we in the Pacific Northwest should profit by the mistakes of others and establish high objectives for the waters of the area and apply such objectives with judgment and especially with a view to future development.

STATEMENT OF POLICY

It is hereby declared to be the policy of the Pollution Control Council of the Pacific Northwest Basins to encourage and promote programs for the preservation of the surface and ground waters of the basins and the restoration of such waters to the best possible condition consistent with the public health and welfare, the propagation and protection of fish and wildlife, and the domestic, recreational, agricultural, and industrial development of the area.

Whereas it is recognized that many waters of the basins have not yet been adversely affected by industrial, agricultural, or domestic development and, therefore, are of the highest possible quality, one objective of any water conservation program should be to preserve these waters in the best condition consistent with reasonable and beneficial future development.

Whereas it is also recognized that other waters in the basin now exist at a level of quality below that which is necessary and desirable for the best interest of the people, a second objective should be to restore these waters to conditions permitting increased beneficial uses by the people of the area.

With these considerations before it, the Council recommends the following objectives of water quality.

INTRODUCTION

I. Definitions

A. Approved treatment as applying to water supplies means treatment accepted as satisfactory by the authorities responsible for exercising supervision over the sanitary quality of water supplies.

B. Source of water supply for culinary or food processing purposes shall mean any source, either public or private, the waters from which are used for domestic consumption or used in connection with the processing of milk, beverages, foods or for other purposes which require finished water meeting U. S. Public Health Service Drinking Water Standards.

C. Fishing shall include the use of waters for the natural and artificial propagation of fish and other aquatic life.

D. Agricultural shall include use of waters for irrigation, stock watering, and other farm purposes but not as a source of water supply for drinking, culinary or food processing purposes.

II. Conditions Applying to Objectives

A. For waters having more than one use, that use having the highest order shall apply.

B. In any case where a tributary water which receives sewage or industrial waste flows into waters having a different use than the tributary, and where these tributary waters affect these uses, the objectives with the highest order will apply.

C. Natural waters may on occasion have characteristics outside of the limits established by the objectives. The objectives set forth relate to the condition of waters as affected by the discharge of sewage, industrial wastes, or other wastes.

A

WATER QUALITY OBJECTIVES AND MINIMU

WATER QUALITY → / WATER USES ↓	WATER QUALITY OBJECTIVES, APPLICABLE TO RECEIVING WATERS, FOR SA WATERS					
	ORGANISMS OF THE COLIFORM GROUP	FLOATING, SUSPENDED & SETTLEABLE SOLIDS & SLUDGE DEPOSITS	TASTE OR ODOR PRODUCING SUBSTANCES	DISOLVED OXYGEN	pH	TOX OTH
A WATER SUPPLY, DRINKING, CULINARY, & FOOD PROCESSING WITHOUT TREATMENT OTHER THAN SIMPLE DISINFECTION AND REMOVAL OF NATURALLY PRESENT IMPURITIES.	MOST PROBABLE NUMBER COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD AVERAGE LESS THAN 50 PER 100 ML. IN ANY MONTH	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES OR OTHER WASTES OR WHICH, AFTER REASONABLE DILUTION & MIXTURE WITH RECEIVING WATERS INTERFERE WITH THE BEST USE OF THESE WATERS FOR THE PURPOSE INDICATED	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES	GREATER THAN FIVE (5) PARTS PER MILLION EXCEPT FOR UNDERGROUND WATERS	HYDROGEN ION CONCENTRATION EXPRESSED AS pH SHOULD BE MAINTAINED BETWEEN 6.5 & 8.5	NONE [illegible] SUBST [illegible] SUPPL [illegible] WATER [illegible] FOR U [illegible]
B WATER SUPPLY, DRINKING, CULINARY, & FOOD PROCESSING WITH TREATMENT EQUAL TO COAGULATION, SEDIMENTATION, FILTRATION, DISINFECTION AND ANY ADDITIONAL TREATMENT NECESSARY FOR REMOVING NATURALLY PRESENT IMPURITIES	M.P.N. COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD AVERAGE LESS THAN 2000 PER 100 ML. AND SHOULD NOT EXCEED THIS NUMBER IN MORE THAN 20 PER CENT OF SAMPLES EXAMINED IN ANY MONTH WHEN ASSOCIATED WITH DOMESTIC SEWAGE	SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH, AFTER REASONABLE DILUTION & MIXURE, WILL INCREASE THE THRESHOLD ODOR NUMBER ABOVE EIGHT (8)	GREATER THAN FIVE (5) PARTS PER MILLION EXCEPT FOR UNDERGROUND WATERS	SAME AS FOR USE "A" ABOVE	SAME AS ABOVE
C BATHING, SWIMMING AND RECREATION NOTE: WHEN WATERS ARE USED FOR RECREATIONAL PURPOSES SUCH AS FISHING & BOATING, EXCLUSIVE OF BATHING & SWIMMING, THE NUMBER "1000" MAY BE SUBSTITUTED FOR "240" IN STATEMENT OF COLIFORM OBJECTIVE	M.P.N. COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD AVERAGE LESS THAN 240 PER 100 ML. AND SHOULD NOT EXCEED THIS NUMBER IN MORE THAN 20 PER CENT OF SAMPLES EXAMINED WHEN ASSOCIATED WITH DOMESTIC SEWAGE*	SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH, AFTER REASONABLE DILUTION & MIXURE, WILL INTERFERE WITH THE BEST USE OF THESE WATERS FOR THE PURPOSE INDICATED	GREATER THAN FIVE (5) PARTS PER MILLION	SAME AS FOR USE "A" ABOVE	SAME AS ABOVE
D GROWTH & PROPAGATION OF FISH, SHELLFISH & OTHER AQUATIC LIFE	M.P.N. COLIFORM BACTERIAL CONTENT OF A REPRESENTATIVE NUMBER OF SAMPLES SHOULD NOT HAVE A MEDIAN CONCENTRATION GREATER THAN 70 PER 100 ML. IN WATERS USED FOR THE GROWTH & PROPAGATION OF SHELLFISH	SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH WILL INTERFERE WITH THE MARKETABILITY OR PROPAGATION OF RECREATIONAL OR COMMERCIAL FISH, SHELLFISH, OR OTHER EDIBLE AQUATIC FORMS	GREATER THAN SIX (6) PARTS PER MILLION	SAME AS FOR USE "A" ABOVE	NONE [illegible] SUBST [illegible] SUPPL SOURCE [illegible] WATER [illegible] FOR
E AGRICULTURAL AND INDUSTRIAL WATER SUPPLY WITHOUT TREATMENT EXCEPT FOR THE REMOVAL OF NATURAL IMPURITIES TO MEET SPECIAL QUALITY REQUIREMENTS, OTHER THAN THOSE CLASSIFIED UNDER "A" ABOVE. NOTE: PERMISSIBLE LIMITS FOR TOTAL CONCENTRATION PER CENT SODIUM, BORON, CHLORIDES, AND SULFATES TO RECEIVE FURTHER STUDY. SUGGESTED VALUE FOR PER CENT SODIUM IS LESS THAN 40. PER CENT SODIUM MEANS THE RATIO OF SODIUM TO TOTAL CATIONS EXPRESSED IN EQUIVALENT WEIGHTS, CALCULATED FROM THE FORMULA Na X 100 / Na + K + Ca + Mg WHEN Na, Ca, AND Mg ARE ALL EXPRESSED IN EQUIVALENTS.		SAME AS FOR USE "A" ABOVE	NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH WILL ADVERSELY AFFECT THE MARKETABILITY OF AGRICULTURAL OR INDUSTRIAL PRODUCE	GREATER THAN THREE (3) PARTS PER MILLION	HYDROGEN ION CONCENTRATION EXPRESSED AS pH SHOULD BE MAINTAINED BETWEEN 6.0 & 9.5	SAME ABOVE

* SEE NOTE UNDER C ABOVE.

LITY OBJECTIVES AND MINIMUM B TREATMENT REQUIREMENTS

PLICABLE TO RECEIVING WATERS, FOR SALT AND FRESH SURFACE WATERS AND UNDERGROUND WATERS							MINIMUM TREATMENT REQUIREMENTS FOR DOMESTIC SEWAGE
TASTE OR ODOR PRODUCING SUBSTANCES	DISOLVED OXYGEN	pH	TOXIC, COLORED, OR OTHER DELETERIOUS SUBSTANCES	PHENOLIC COMPOUNDS	OIL	HIGH TEMPERATURE WASTES	
NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES	GREATER THAN FIVE (5) PARTS PER MILLION EXCEPT FOR UNDERGROUND WATERS	HYDROGEN ION CONCENTRATION EXPRESSED AS pH SHOULD BE MAINTAINED BETWEEN 6.5 & 9.5	NONE ALONE OR IN COMBINATION WITH OTHER SUBSTANCES OR WASTES IN SUFFICIENT AMOUNTS OR OF SUCH NATURE AS TO MAKE RECEIVING WATER UNSAFE OR UNSUITABLE FOR USE INDICATED (U.S.P.H.S. 1950.)	LESS THAN FIVE (5) PARTS PER BILLION	NONE	NOT IN SUFFICIENT QUANTITIES ALONE OR IN COMBINATION WITH OTHER WASTES TO INTERFERE WITH THE USE INDICATED	PRIMARY TREATMENT AND EFFECTIVE DISINFECTION
NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH, AFTER REASONABLE DILUTION & MIXTURE, WILL INCREASE THE THRESHOLD ODOR NUMBER ABOVE EIGHT (8)	GREATER THAN FIVE (5) PARTS PER MILLION EXCEPT FOR UNDERGROUND WATERS	SAME AS FOR USE "A" ABOVE	SAME AS FOR USE "A" ABOVE	LESS THAN FIVE (5) PARTS PER BILLION	NONE ALONE OR IN COMBINATION WITH OTHER SUBSTANCES OR WASTES AS TO MAKE RECEIVING WATER UNFIT OR UNSAFE FOR THE USE INDICATED	SAME AS FOR USE "A" ABOVE	PRIMARY TREATMENT AND EFFECTIVE DISINFECTION
NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH, AFTER REASONABLE DILUTION & MIXTURE, WILL INTERFERE WITH THE BEST USE OF THESE WATERS FOR THE PURPOSE INDICATED	GREATER THAN FIVE (5) PARTS PER MILLION	SAME AS FOR USE "A" ABOVE	SAME AS FOR USE "A" ABOVE	LESS THAN 25 PARTS PER BILLION OR SOME IN SUFFICIENT AMOUNTS SUCH AS TO IMPART A RESIDUAL TASTE TO RECREATIONAL OR COMMERCIAL FISH, SHELLFISH, OR OTHER AQUATIC FORMS	SAME AS FOR USE "B" ABOVE	SAME AS FOR USE "A" ABOVE	PRIMARY TREATMENT AND EFFECTIVE DISINFECTION
NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH WILL INTERFERE WITH THE MARKETABILITY OR PROPAGATION OF RECREATIONAL OR COMMERCIAL FISH, SHELLFISH, OR OTHER EDIBLE AQUATIC FORMS	GREATER THAN SIX (6) PARTS PER MILLION	SAME AS FOR USE "A" ABOVE	NONE ALONE OR IN COMBINATION WITH OTHER SUBSTANCES OR WASTES IN SUFFICIENT AMOUNT OR OF SUCH CHARACTER AS TO MAKE RECEIVING WATERS UNSAFE OR UNSUITABLE FOR USE INDICATED	SAME AS FOR USE "C" ABOVE	SAME AS FOR USE "B" ABOVE	NOT IN SUFFICIENT QUANTITY AS TO INCREASE THE TEMPERATURE OF THE RECEIVING WATER BEYOND THAT OPTIMUM FOR THE NORMAL AQUATIC LIFE OF THE SPECIFIC WATER	PRIMARY TREATMENT FOR ALL USES UNDER THIS GROUP BUT DISINFECTION REQUIRED IN ADDITION ONLY IF DISCHARGED INTO WATERS USED FOR THE GROWTH & PROPAGATION OF SHELLFISH, EITHER COMMERCIAL OR RECREATIONAL
NONE ATTRIBUTABLE TO SEWAGE, INDUSTRIAL WASTES, OR OTHER WASTES WHICH WILL ADVERSELY AFFECT THE MARKETABILITY OF AGRICULTURAL OR INDUSTRIAL PRODUCE	GREATER THAN THREE (3) PARTS PER MILLION	HYDROGEN ION CONCENTRATION EXPRESSED AS pH SHOULD BE MAINTAINED BETWEEN 6.0 & 9.5	SAME AS FOR USE "A" ABOVE	NONE IN SUFFICIENT QUANTITY AS TO MAKE RECEIVING WATER UNSUITABLE FOR USE INDICATED	SAME AS FOR USE "B" ABOVE	SAME AS FOR USE "A" ABOVE	PRIMARY TREATMENT AND EFFECTIVE DISINFECTION